CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

The Proposed Action is the construction and operation of Nathan Dam (on the Dawson River in Central Queensland) and associated water delivery infrastructure. The Project was referred to the Commonwealth Minister for the Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC), then the Department of Environment, Water, Heritage and the Arts (DEWHA), in June 2008. On 30 July 2008, the Commonwealth Minister determined that the Project is a "controlled action" under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) due to the likely potential impacts on matters of national environmental significance (NES). The controlling provisions under the EPBC Act are:

- sections 12 and 15A (World Heritage properties);
- sections 15B and 15C (National Heritage places);
- sections 16 and 17B (Wetlands of International Importance);
- sections 18 and 18A (Listed threatened species and ecological communities);
- sections 20 and 20A (Listed migratory species); and
- sections 23 and 24A (Commonwealth marine areas).

The Great Barrier Reef Marine Park is located some 620 km downstream of the dam. Assessment of impacts on downstream flows and water quality indicates that significant impacts on the World Heritage Values of the Marine Park are unlikely. The Shoalwater and Corio Bay Wetlands of National Environmental Significance are similarly separated from the Project area and significant impacts are unlikely. The level of potential risk to the marine environment is assessed as low.

Four EPBC listed 'endangered' ecological communities are identified as occurring within the broader Project area;

- Brigalow (*Acacia harpophylla* dominant and co-dominant);
- natural grasslands of the Queensland Central Highlands and the northern Fitzroy Basin;
- semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions; and
- the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin (GAB discharge spring wetlands).

Impacts on semi-evergreen vine thickets have been avoided. Impacts on the natural grasslands can be avoided by minimising the width of the pipeline easement adjacent to the single natural grassland patch.

Clearing for the dam, pipeline and road upgrades will result in the loss of up to 212.9 ha of Brigalow. This will be minimised to some extent by realigning the final pipeline route to avoid or at least traverse the edges of Brigalow, minimising the construction width and rehabilitating the construction easement post-construction. Offsets will be provided to compensate for the residual loss of Brigalow.

Inundation to Full Supply Level (FSL) will result in the loss of 28 GAB spring wetlands. This equates to a reduction of 11% of the GAB springs in the Springsure Supergroup, however, only affects 1 of 12 spring supergroups that occur nationally. SunWater is of the view that springs in this area do not meet the definition of the threatened ecological community.

GAB spring wetlands outside the FSL will also be subject to increased groundwater pressure resulting in increased groundwater flow which is likely to cause wetlands to expand. It is highly likely that new springs will also be created. These communities will be protected and monitored to observe any changes in biotic factors.

No listed threatened flora species were recorded from the Project area during the field survey. However, Hairy Joint Grass (*Arthraxon hispidus* - vulnerable) was recorded above FSL and is likely to occur within the water storage area. One threatened flora species is considered a likely occurrence along the pipeline corridor; Curly Bark Wattle (*Acacia curranii*- vulnerable).

Two listed threatened fauna species were recorded from the Project area, the Boggomoss Snail (*Adclarkia dawsonensis* – critically endangered) and Squatter Pigeon (Southern) (*Geophaps scripta* - vulnerable). Four additional species are considered likely to occur in the Project area, Brigalow Scaly-foot (*Paradelma orientalis* – vulnerable), Ornamental Snake (*Denisonia maculata* - vulnerable), Australian Painted Snipe (*Rostratula australis* - vulnerable) and Fitzroy River turtle (*Rheodytes leukops* - vulnerable).

Research undertaken for this EIS has increased the number of sites from which the Boggomoss Snail has been recorded from two to 17 and the estimated population from about 850 to 29,796. One subpopulation of the Boggomoss Snail will be inundated by the dam from three boggomosses at Mt Rose station. The proponent proposes to translocate snails found at those sites to existing and new sites within the range of the species. These and other sites will be protected and monitored. Other actions within the Recovery Plan will also be undertaken. With mitigation it is considered that a significant impact on the species is not likely.

While evidence of the existence of Fitzroy River turtle in the Project footprint relates only to a reference to a photograph, the assessment of impacts and the need for mitigation measures has been based on the assumption that the species is present. It has been confirmed as living and breeding in weir pools downstream of Nathan Gorge. A range of habitat management measures and a dedicated turtle passage to allow movement passed the dam have been included within the Project. As a result, it is assessed that a significant impact on the species is not likely.

Four listed Migratory species are known from the Project area; White-bellied Sea-eagle (*Haliaeetus leucogaster*), White-throated Needletail (*Hirundapus caudacutus*), Cattle Egret (*Ardea ibis*), and Rainbow Bee-eater (*Merops ornatus*). A further four migratory species are considered likely to occur in the Project area; Cotton Pygmy Goose (*Nettapus coromandelianus albipennis*), Satin Flycatcher (*Myiagra cyanoleuca*), Rufous Fantail (*Rhipidura rufifrons*) and Great Egret (*Ardea alba*). Impacts on migratory species are likely to be low, or in the case of wetland migratory species, positive.

Impacts on all other known and likely threatened species and the threatened ecological community (Brigalow) are likely to be low.

Consequential actions and cumulative impacts of the proposed action have been considered. It is considered that there are two core environmental issues associated with cumulative impact with other projects: changes to the flow regime and clearing of vegetation. As part of the hydrologic assessment a cumulative impacts scenario was modelled. Overall, the impacts of the cumulative impacts scenarios are moderate and will be able to be managed through a combination of environmental flow releases and management rules. These will need to be developed as the other proposed infrastructure is approved and finalised. The clearing of vegetation will be offset by protection and rehabilitation of

extensive tracts of habitat around and downstream of the water storage. With mitigation and offsets there is not expected to be a net loss of significant vegetation and habitat for threatened species, and thus cumulative impacts with other projects in the region (i.e. Wandoan Coal Mine), which are themselves required to provide offsets, are expected to be low.

28. MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

28.1. Introduction

On 18 April 2008, the Queensland Coordinator-General (CG) declared the Project a 'significant project', for which an Environmental Impact Statement (EIS) is required pursuant to section 26(1)(a) of the *State Development and Public Works Organisation Act 1971* (SDPWO Act).

On 30 July 2008, the Commonwealth Minister for the Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC) determined that the Project is a "controlled action" under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) due to the likely potential impacts on matters of national environmental significance (MNES). The controlling provisions under the EPBC Act are:

- sections 12 and 15A (World Heritage properties);
- sections 15B and 15C (National Heritage places);
- sections 16 and 17B (Wetlands of International importance);
- sections 18 and 18A (Listed threatened species and communities);
- sections 20 and 20A (Listed migratory species); and
- sections 23 and 24A (Commonwealth marine areas).

The Nathan Dam and pipelines project EIS has been developed pursuant to the bilateral agreement between the Australian and Queensland governments for the purposes of the Australian Government's assessment under Part 8 of the EPBC Act. The Terms of Reference (ToR) for the Project specify that the EIS should address potential impacts on the MNES identified at the time the Project was determined to be a controlled action. Furthermore, the ToR (Section 1.10.3) requires a stand-alone report be provided as part of the EIS that exclusively and fully addresses the issues relevant to the controlling provisions in accordance with the following outline:

- introduction;
- description of proposed action (as it would impact on MNES);
- description of the affected environment relevant to the controlling provisions (i.e. describe the features of the environment that are MNES protected under the EPBC Act);
- assessment of impacts on MNES and mitigation measures (in accordance with available guidelines and species recovery plans);
- an outline of the environmental management plan that sets out the framework for continuing management, mitigation and monitoring for the relevant impacts of the action and the name of the agency responsible for endorsing or approving each mitigation measure or monitoring programme;
- environmental record of the person proposing to take the action (proponent) — including details of any proceedings under a Commonwealth, state or territory law for the protection of the environment or the conservation and sustainable use of natural resources against the proponent and for an action for which the person has applied for a permit; if the proponent is a corporation details of the corporation;
- conclusions; and
- references and linkages to relevant sections of the main EIS.

Section 8 of the ToR specifically addresses MNES and provides further detail with respect to the description of and assessment of impacts on MNES. Essentially, impacts are to be assessed in accordance with *EPBC Act Policy Statement 1.1 - Significant Impact Guidelines (Matters of National Environmental Significance*). This report responds to the ToR and is presented in a format which accords with the ToR.

28.2. Description of the proposed action

The Project is the construction and operation of Nathan Dam on the Dawson River in Central Queensland and associated water delivery infrastructure (Figure 28-1).

Water from the dam will be transported via a trunk pipeline to primarily service coal mines and power stations (and associated urban communities) in the Surat Basin, extending to Dalby (Figure 28-1). Water will also be released downstream of the dam, to mines in the Southern Bowen Basin, to existing and potentially new customers in the Dawson Valley Water Supply Scheme, and as required to meet critical urban supply needs in the lower Fitzroy and other parts of Queensland in accordance with the Queensland government's objective to establish a state water grid.

The dam wall will consist of an Earth and Rockfill (E&R) embankment spanning 1240 m. The main spillway is situated on the right abutment.

The capacity of the dam will be 888,312 Megalitres (ML) at an FSL of 183.5 m Australian Height Datum (AHD) and it will inundate an area of approximately 13,508 hectares (ha) from a catchment of 23,185 km^2 (Figure 28-1). The yield of the dam is approximately 66,011 ML/a of high priority or equivalent water (Chapter 14). No new medium priority water is proposed as part of the Project.

Supplemented water is currently available in the Dawson catchment as either high priority, medium priority or medium priority A. These products have different associated levels of security of supply. Medium priority is generally used for agriculture while high priority is used for industrial and urban allocations.

The pipeline will be mostly buried and largely follow existing easements south then southeast of the dam over a distance of approximately 260 km to Dalby. The delivery system will include four pump stations and three balancing storages, as well as air valves, scours, surge tanks and standpipes.

The Project also includes the following components:

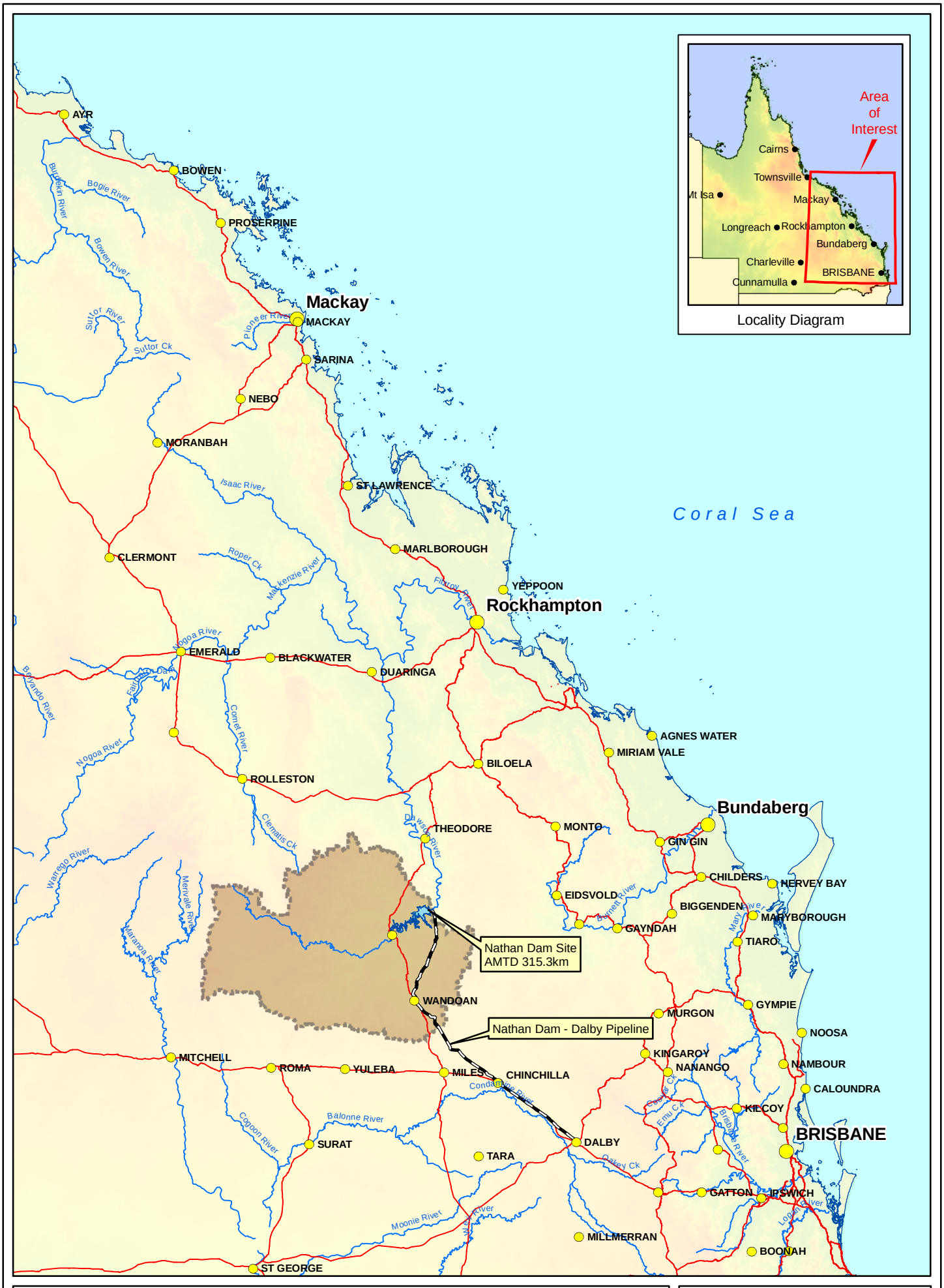
- establishing resource extraction areas (primarily clay extraction);
- constructing a dam site access road;
- relocating, raising or otherwise upgrading sections of local government roads and state controlled roads;
- providing new property access where required;
- relocating local power and telecommunications infrastructure and providing new infrastructure;
- removing or treating redundant infrastructure (such as Glebe Weir);
- relocating private infrastructure required to support continued use of land not affected by the Project;
- constructing various related facilities such as offtake and outlet works, fish and aquatic fauna transfer devices, protective works and recreational facilities; and
- providing access tracks to the pipeline easement.

Operation of the water storage involves maintenance of the dam infrastructure (including a small buffer area to the infrastructure), the land inundated at FSL and also additional land above the FSL based on the peak surface water level reached during a 1 in 100 AEP (Annual Exceedance Probability) flood. The exact location of land included in the flood buffer area will have regard to specific site characteristics such as slope, vegetation, location of improvements and infrastructure and will be finalised in consultation with individual landholders. This defined water storage area (including the flood buffer area) represents the minimum land requirement for the Water Storage.

Operation of the water distribution infrastructure involves maintenance of the pipes, valves, surge tanks, standpipes, scours, access tracks and other structural components which will be primarily located with a permanent easement of 15 m width. A temporary easement of 30 m width will be required for construction. Operational infrastructure also includes balance tanks and pump stations for which land will be acquired. In some cases land may also be acquired for surge tanks.

All of the above components represent the proposed Project Designation Area referred to in the EIS text as the Project Area.

Construction of both the dam and pipeline will follow a similar timeline. Early works are planned to commence late 2013 with major construction commencing in early 2014. A two year construction program will result in commissioning of the dam and pipeline in mid 2016.


Area of Interest
Cairns
Townsville
Mt Isa
Mackay
Longreach
Rockhampton
Bundaberg
Charleville
BRISBANE
Cunnamulla
Locality Diagram
Coral Sea
AYR
BOWEN
PROSERPINE
Mackay
MACKAY
SARINA
NEBO
MORANBAH
ST LAWRENCE
MARLBOROUGH
CLERMONT
YEPPOON
Rockhampton
EMERALD
BLACKWATER
DUARINGA
AGNES WATER
MIRIAM VALE
BILOELA
ROLLESTON
Bundaberg
THEODORE
MONTO
GIN GIN
CHILDERS
HERVEY BAY
EIDSVOLD
BIGGENDEN
MARYBOROUGH
GAYNDAH
TIARO
Nathan Dam Site
AMTD 315.3km
WANDOAN
GYMPIE
MURGON
Nathan Dam - Dalby Pipeline
NOOSA
KINGAROY
NANANGO
NAMBOUR
MITCHELL
ROMA
YULEBA
MILES
CHINCHILLA
CALOUNDRA
KILCOY
BRISBANE
SURAT
DALBY
TARA
GATTON
IPSWICH
MILLMERRAN
BOONAH
ST GEORGE
Isaac River
Suttor River
Suttor Ck
Pioneer River
Bogie River
Burdekin River
Bowen River
Roper Ck
Mackenzie River
Fitzroy River
Nogoa River
Comet River
Clematis Ck
Dawson River
Warrego River
Merivale River
Warrana River
Fairbairn Dam
Bottle Tree Ck
Nogoa River
Condamine River
Balonne River
Cogoon River
Moonie River
Oakey Ck
Emu Ck
Brisbane River
Logan River
Mary River
Barnett River
LEGEND
Towns
Major Roads
Major Rivers
Nathan Dam Catchment
Projection: GDA94 Zone 56
Figure 28-1
0 15 30 60 90
Kilometres
Scale 1:4,000,000 (at A4)
SW 233053B
N
SKM
SunWater
Making Water Work
NATHAN DAM AND PIPELINES EIS
Locality plan

28.2.1. Location

28.2.1.1. Dam and surrounds

The dam site is located on the Dawson River at Adopted Middle Thread Distance (AMTD) 315.3 km which is approximately 70 km downstream of Taroom along the river, some 11 km downstream of Glebe Weir and 5 km upstream of Nathan Gorge (Figure 28-1). Gyranda Weir is below Nathan Gorge and some 30.8 km downstream from the dam site. The total river distance from the dam site to the Fitzroy River mouth is approximately 620 km (Figure 28-1).

The water storage is entirely within Banana Shire Local Government Area (LGA) whilst the pipeline commences in Banana Shire LGA and extends into Western Downs Regional Council (WDRC) area. The downstream distribution area constitutes the Dawson Valley Water Supply Scheme and the Dawson and Fitzroy rivers as included within the Fitzroy Basin Water Resource Plan (WRP 1999).

The major land uses in the immediate area of the dam are grazing with some irrigation, primarily of fodder, near the Dawson River. Taroom is the closest town along the river upstream of the dam site and has a population of 633 (ABS 2006 census). Theodore is the closest town along the river downstream (85 km) and has a population of 444. The minimum area of land to be acquired for the water storage area is approximately 24,644 ha. This comprises 13,824 ha within the FSL, 10,603 ha of flood buffer and 217 ha of construction area and associated buffer.

The Queensland Government stood in the market for properties related to the Project Area from 1996 to 2009 and currently owns approximately 50% of the required land. In most cases the land is being leased back to the previous landholders. Should the Project be approved to proceed, the Government will continue to seek to voluntarily purchase only that part of a property that is required for the Project. Some landowners may elect to sell their entire properties rather than part, in which case the Government may agree to purchase the whole of their property.

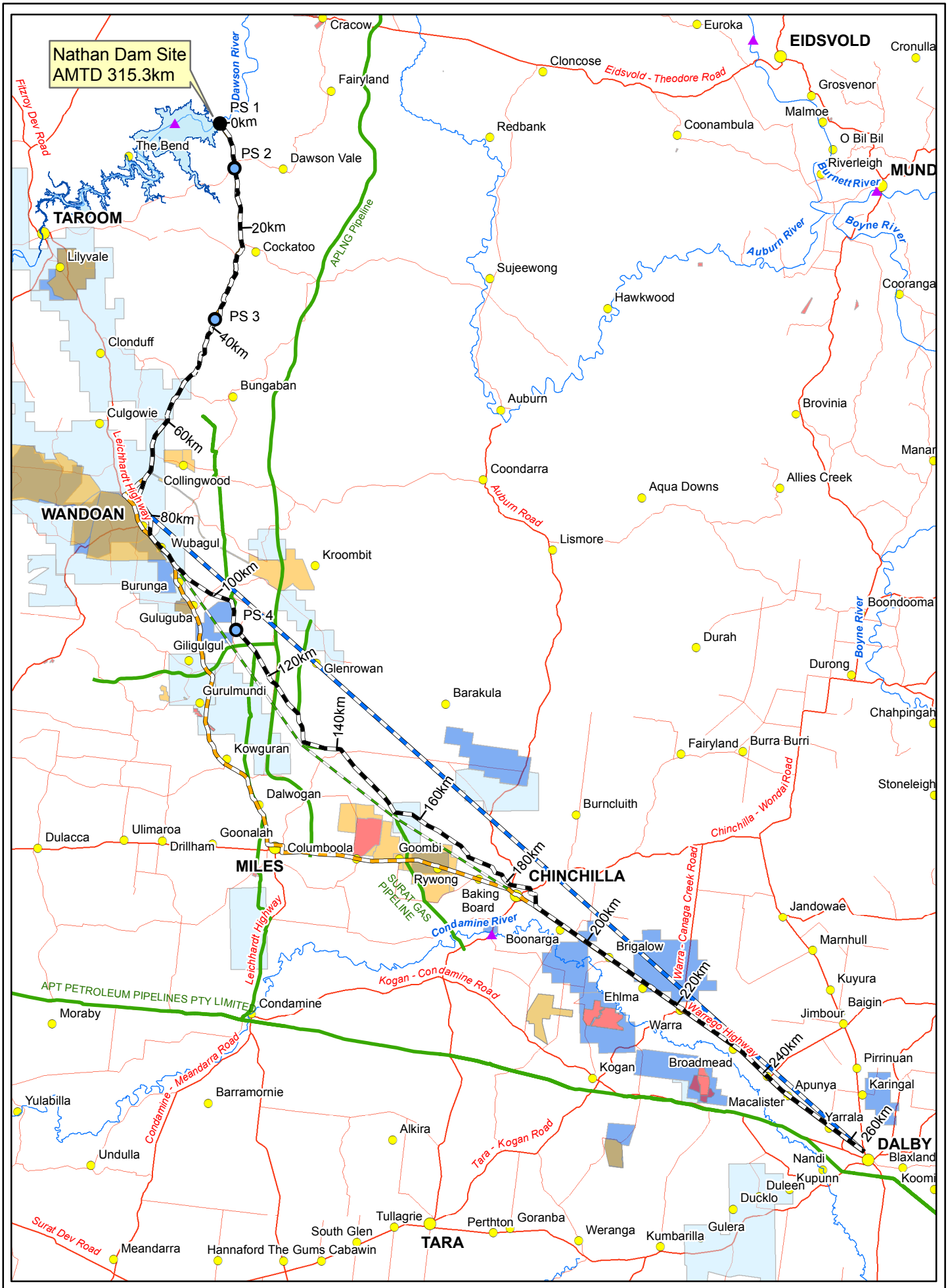
The land surrounding the water storage which is purchased or leased as part of the Project will be managed in part for the purpose of riparian zone rehabilitation and obtaining environmental offset related values.

28.2.1.2. Pipeline

The pipeline route extends from the water storage to Nathan Road, follows Nathan Road to Wandoan, south-east from Wandoan across private property to Chinchilla, then follows the Warrego Highway to Dalby (Figure 28-2).

The pipeline construction easement is 30 m wide, 15 m either side of the pipeline centreline. This is the maximum easement width required for construction, however depending on topography and access requirements, it will be possible to reduce this width to as little as 15 m to minimise impact where the pipeline traverses sensitive environmental areas. For all area calculations an easement of 30 m has been assumed irrespective of whether it is partially or wholly contained within another easement. The pipeline will be primarily buried except in areas of hard rock. The route follows existing easements for approximately two thirds of its length, although just under half of the pipeline easement will actually be located within existing cleared easements. In addition to the pumps at the dam site, three pump stations and associated balancing storages will be required along the route. These will have additional site preparation requirements.

The operational easement of the pipeline route will be 15 m wide. This will include a vehicle access track approximately 3 m wide adjacent to the pipeline to allow inspection and maintenance activities.



LEGEND

- Pump Station
- Pump Station & Balancing Storage
- Gas Pipeline

Mining Leases
- Application
- Granted

Mineral Dev. Licences
- Application
- Granted

Nathan Dalby Pipeline
- Option 1
- Option 2
- Option 3
- Final Alignment

Projection: GDA94 Zone 56

Figure 28-2

0 5 10 20 Kilometres

Scale 1:900,000 (at A4)

SW 237633C

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Nathan Dam to Dalby Pipeline

28.2.1.3. Associated infrastructure

Some new infrastructure will be required for construction and operation of the Project. Additionally, the storage or pipeline will require new or upgraded power and telecommunications to satisfy operational needs. The construction of the Project requires resource supplies of rock and sand, a raw water supply and systems for the treatment and disposal of waste water. The associated infrastructure required for the water storage component of the Project comprises:

- decommissioning of Glebe Weir;
- new 6.5 km dam access road from the north, being an extension of the existing Glebe Weir Road;
- upgrade Glebe Weir Road to the Spring Creek junction and intersection with the Leichardt Highway;
- closing the Bundulla Road crossing of the Dawson River and portion of Glebe Weir Road near Glebe Weir;
- realignment of The Bend Road and Brodies Road;
- new rural road bridge or causeway on Cracow Road at Cockatoo Creek and Bentley Creek;
- resource extraction areas for construction materials. Requirements will be purchased from licensed suppliers operating under separate approvals except for clay, which the construction contractor will source from within the water storage area. A combination of suppliers or sources will be required to satisfy the resource demand. Preference will be given to closest existing licensed sources or suppliers;
- recovery of existing 11 kV and 33 kV overhead power lines and associated infrastructure;
- construction of new power and telecommunications infrastructure to service the dam site during construction and operation and to the pump stations;;
- construction of septic tanks at the dam site office and dry composting toilets at the new recreation facilities; and
- provision of two recreation areas and viewing platform at the dam.

The pipeline will traverse power, telecommunications, water, and sewerage infrastructure, however infrastructure will not be impacted by the pipeline and services will be maintained throughout construction. Infrastructure associated with the pipeline includes two temporary construction camps at Wandoan and Chinchilla.

Key aspects of the water storage are presented in Table 28-1.

Table 28-1 Key parameters of the water storage

Parameter	Description
Full Supply Level	183.5 m AHD
Total width, spillway and embankments	1240 m
Area inundated at FSL	13,508 ha (excl. islands)
Storage capacity at FSL	888,312 ML
Dead storage	34,502 ML
Yield	66,011 ML/a (high priority or equivalent)
Maximum depth at FSL	23 m
Average depth at FSL	7.4 m
Spillway crest height above stream bed	23.5 m
Maximum structure height above stream bed	Approximately 38 m

Parameter	Description
Saddle dam length and max height	730 m long and up to 8 m high
Length of Dawson River inundated at FSL	75.2 km
Length of major streams inundated at FSL:	
Spring Creek	7.0 km
Cockatoo Creek	27.5 km
Boggomoss Creek / Spring Gully	10.9 km (combined)
Binghi Creek	9.3 km
Bentley Creek	10.3 km
Double Stable Yard Creek	4.5 km
Blackboy Creek	4.7 km
Scotchy Creek	4.6 km
Palm Tree Creek	12.0 km

28.2.2. Design

28.2.2.1. Earth and rockfill dam

The preliminary design for an earth and rockfill (E&R) dam involves an earth (clay, sand) and rockfill embankment with maximum base thickness approximately 280 m tapering upwards to a crest 8 m wide with a roadway providing access to the spillway. Slopes on both faces of the embankment are set at 2.5 horizontal to 1 vertical and contain a weighting zone to increase stability. Chapter 2 provides a description of the Project including figures to illustrate the design.

Rock excavated during spillway construction will be used as rockfill in the dam structures. The diversion conduit and outlet works would be located on the right abutment to allow simple access to the intake tower and, because it is closer to the river channel, it will assist in attracting fish to the fishway.

Weathering resistant stone (rip rap) imported to the site will provide wave protection on the upstream face of the embankment. Coarse, reinforced sandstone rockfill will provide weather protection on the downstream face and erosion protection in the event of overtopping during construction. The embankment is designed not to overtop on completion.

An engineering summary of the principal features of the E&R Dam is shown in Table 28-2.

Table 28-2 Engineering summary for the earth and rockfill Dam

Parameter	Description
Location	Dawson River AMTD 315.3 km
Crest Elevation	EL 201 m AHD
Crest Width	8 m
Embankment Length	Approx 1240 m
Embankment Base Width	Maximum 280 m

28.2.2.2. Spillway

The spillway comprises an entry channel with invert level at 180.0 m AHD and a 3.5 m high, mass concrete ogee (a shape consisting of a concave arc flowing into a convex arc), and un-gated control crest. The spillway is flanked by concrete facings anchored to exposed rock in the sides of the spillway channel.

The apron at the downstream toe of the ogee crest falls uniformly, that is, it is smooth, to a shallow flip bucket. The flip bucket lip directs high flows to an excavated plunge pool 200 m wide with a base at 160 m AHD. This will dissipate flow energy in such a way that minimises stress to fish or turtles passing over the spillway while achieving minimal erosion downstream of the dam wall.

The meander of the river means the plunge pool has been designed to discharge into an excavated channel prior to discharge into the Dawson River downstream of the dam embankment.

The steep face below the flip bucket lip will be concrete-faced to protect the rock from weathering and erosion.

The spillway width is yet to be optimised and may vary between 200 m and 300 m. The narrow 200 m width has been used for flood studies and will safely discharge the Probable Maximum Flood (PMF) peak inflow of 25,280 m^3/sec. The 200 m wide spillway will pass the 1 in 100 AEP flood with a peak water surface elevation of 187.3 m, approximately 3.8 m above the spillway crest. A small portion (approximately 11 m wide) of the spillway will have flap gates. These gates will enable a discharge of 230 m^3/s to enable the post-winter flow objectives of the Water Resource Plan to be met.

An engineering summary of the principal features of the spillway is shown in Table 28-3.

The precise details of the spillway profile and energy dissipation arrangements will have to be determined and optimised by physical hydraulic modelling. Accordingly, some changes in the dissipator arrangements may be anticipated during the detailed design phase. Notwithstanding, the general appearance, layout and footprint of the spillway will not change significantly.

Table 28-3 Summary of engineering details of the conceptual design for main spillway

Parameter	Description
Spillway Type	Ogee and flip bucket
Spillway Crest Elevation	EL 185.3 m AHD
Crest Design Head	4.7 m
Total Main Spillway Width	200 m
Energy Dissipation Method	Plunge Pool (to be confirmed by physical hydraulic model)

28.2.2.3. Saddle dam

The saddle dam will be of similar cross section and detail to the E&R dam. An engineering summary of the principal features of the saddle dam is shown in Table 28-4.

Table 28-4 Engineering summary of saddle dam

Parameter	Description
Location	Approximately 1150 m south east of the dam wall.
Description	E&R
Crest Elevation	201 m AHD
Crest Width	8 m
Embankment Length	730 m

28.2.2.4. Intake structure

The selective withdrawal system (multi-level offtake) provides for both downstream and pipeline release of water and consists of a series of closed baulks and open trashrack panels that can be located in any order down the baulk and trashrack slot. The draw off level is selected by positioning the trashrack panels at the level of the best quality water available from the storage and opening the downstream valves. The trashrack panels protect the outlet facilities from floating debris of a size that may damage outlet works components or jam valves. In addition to the trashrack panels, a large area of fine screen is provided to prevent fauna being drawn through the outlet works or being forced onto the screens themselves. The fine screens are oriented so as to direct fish toward the entrance chamber of the fishway. These elements have been discussed with relevant government agencies and fauna experts and these discussions will continue throughout detailed design.

28.2.2.5. Outlet works

The basic elements of the downstream outlet works comprise the intake structure described in the preceding section and a number of outlet conduits with facilities to regulate and control flow. In addition, the water supply for the fishway and pipeline is also drawn from the conduit. The principal features of these outlet components are summarised in Table 28-5.

The primary river outlet facilities are a reinforced concrete steel lined conduit within the right abutment of the dam. Discharge will be controlled by a wheeled gate at the downstream end. A bulkhead gate will serve as a guard gate while the downstream gate acts as the regulating gate. A secondary river outlet facility is provided by way of a regulating valve fitted to the tunnel. This valve is intended to meet the environmental flow objectives of the Water Resource Plan. This secondary outlet is also suited to use at times when small releases are required.

The water supply for the fishway is also drawn from the conduit that supplies the secondary outlet valve. The other circular steel conduit supplies the pipeline water supply low head pumps and the local domestic water supply for the dam and its associated facilities.

The precise arrangement for these facilities will be optimised during final design and hence the layout and size may change marginally. However, the required outlet capacity will be maintained.

Table 28-5 Description of outlet elements

Parameter	Description
Primary River Outlet	3000 mm outlet controlled by a gate located at downstream end of conduit
Outlet Works Capacity	45 m^3/sec (3888 ML/day)

28.2.2.6. Fishway

A fishway has been included in the preliminary design to accommodate both upstream and downstream fish movement. Initial discussions have been undertaken with Queensland (DEEDI) and DERM staff. The design described in this section is conceptual and developed as part of agency discussions. The design of the fishway will be finalised during detailed design following further consultation with relevant agencies and experts and in general accordance with the process provided by Queensland Fisheries.

As the fishway will need to operate over a height of 38 m, the most effective means of moving fish past the dam wall is likely to be a fish lift. The expected efficiency of this approach to fish movement is discussed in Chapter 13 Aquatic Fauna.

28.2.2.7. Turtleway

A dedicated turtleway has been included in the preliminary design to accommodate both upstream and downstream turtle movement. Initial discussions have been held with DERM and design of the facility will be finalised during the detailed design stage following further consultation with relevant agencies and experts.

28.2.2.8. Trunk pipeline

The design flow rate for the trunk pipeline, based on an operation period of 20 hours/day and 350 days/year, is 1766 L/s, for an annual capacity of 44,500 ML. The proposed pipe has a nominal diameter of 1200 mm, although the diameter is likely to be reduced to approximately 400 mm as demand reduces towards the Dalby end of the pipeline.

The pipeline will largely be buried except for a 45 km section where it may be above ground due to shallow rock. Where underground, the pipeline will be constructed from mild steel cement lined (MSCL) pipe, with a minimum earth cover of 900 mm, possibly increasing up to about 2500 mm over short lengths. The pipeline will be bedded in sand or similar inert material throughout its length. Surrounding the pipes with sand provides a stable environment and appropriate structural support. The design life of the pipeline is 50 years.

A low head pump station will be constructed at the dam. The preliminary design provides for these pumps to be located in a well adjacent to the outlet works valve chamber. The second pump station will contain conventional high lift centrifugal pumps which will draw water from a 5 ML concrete balance tank at the site which is filled by the low lift pumps at the water storage. The two additional relift pump stations will have a 50% standby capacity. The first also uses a 5 ML concrete balance tank while the second has a 600 ML earthen balance tank.

The pipeline has sought to minimise the impact on remnant vegetation and habitat through route selection. Recommendations from the field surveys were implemented to avoid areas of remnant vegetation and habitat where possible.

28.2.3. Pre-construction activities

Pre-construction activities include:

- acquiring the necessary land or access to land;
- obtaining all necessary permits and approvals (addressed in Section 1.10);
- clearing vegetation;
- site decontamination;
- upgrading and constructing access roads and implementation of traffic management plan;
- extending power and communications facilities to the water storage construction site;
- establishing site office facilities and secure compounds;
- establishing workforce accommodation;

- establishing resource extraction sites; and
- transporting construction materials to stockpiles.

28.2.3.1. Vegetation clearing and fauna relocation

Vegetation clearing and fauna relocation will be undertaken at all work sites, including the water storage area, trunk pipeline route, road works and resource extraction sites. The process described below is generally applicable to all sites.

Trees and shrubs will be cleared to FSL within the water storage area, except where significant vegetation is near FSL or in the riparian zone of tributaries and the main channel which will be cleared to within 1.5 m (vertical) of FSL. In this case it will be left in place as it may survive, depending on inundation frequency and duration. Millable timber, or timber suited to artisans will be sold. A proportion of remaining woody vegetation may be mulched for use in construction site rehabilitation and landscaping of recreational facilities.

Appropriate material will be salvaged for use as 'large woody debris' fish habitat, or terrestrial habitat above frequent flood inundation levels. Remaining material, of which little is expected, will be pit-burnt on site under permit from the local fire warden.

Vegetation clearing will be undertaken in stages, commencing with the area required for construction works around the dam wall. The remainder will be cleared progressively until the water storage is ready to fill.

Approval for clearing is required under the Queensland *Vegetation Management Act 1999* (VM Act), Queensland *Nature Conservation Act 1992* (NC Act) and possibly the EPBC Act (Section 1.10). Measures to be incorporated into a clearing plan include:

- the presence of fauna spotter/catcher(s) accredited by Queensland Parks and Wildlife Service (QPWS) during vegetation clearing for safe handling and possible translocation of animals unable to safely move away from the disturbance;
- management procedures for the treatment of any injured animals; and
- clearing of vegetation to be undertaken so that any more mobile, non-volant (cannot fly) fauna is able to move to other areas of suitable habitat, i.e., patches of habitat should not be disconnected in a haphazard fashion that limits movement.

The fauna spotter/catcher is responsible for:

- actively searching all habitat within areas to be cleared and identifying wildlife species present; and
- facilitation of clearing activities, ensuring methods used are appropriate with minimal risk of injury or death to resident wildlife in accordance with the EMP and the instructions of the construction site manager.

As a rule, the fauna spotter/catcher will work ahead of proposed clearing activities and check vegetation and fauna habitats for the presence of native species. The most desirable approach is to allow wildlife to move out of the disturbance area under their own volition.

28.2.4. Construction of the dam

The dam consists of three individually positioned structures: an E&R embankment, spillway and saddle dam. The construction of these structures is discussed in the following sections.

28.2.4.1. Diversion channel and coffer dams

Having regard to the flood hydrology, topography, dam layout and geotechnical conditions at the site, a river diversion channel around the works is necessary. This diversion channel has a base at elevation 158 m AHD and is excavated into solid sandstone. With a capacity of 230 m^3/s the river channel would have a 20% chance of being exceeded during the dry season (April to October). The excavation of the channel constitutes the start of the bulk earthworks. The material excavated from the diversion channel can be used in the construction of the coffer dams or be hauled to a stockpile for later re-use.

When the diversion channel passes the dam axis, preparations for the dam wall foundation can commence.

28.2.4.2. Dewatering

Before installing the chimney filter, a dewatering program may be undertaken to draw down the water table in the vicinity of the proposed dam wall foundation. It is anticipated that dewatering bores will be located around the excavation with some drilled to depths above the sandstone foundation and others below it. The bores will be pumped initially at a high rate until dewatering has been achieved, reducing to a lower, maintenance rate to keep the excavated area dry. Dewatering is expected to occur over a period of approximately 50 days.

The bore drilling, construction and development methods will be in accordance with the Minimum Construction Requirements for Water Bores in Australia (Land and Water Biodiversity Committee, 2003). The final bore construction details will be designed by a supervising hydrogeologist as each borehole is drilled, to ensure target yields are obtained for the localised ground conditions encountered.

Any bore drilled below a depth of six metres will require the use of a licensed groundwater driller who is registered under the *Water Act 2000*. The dewatering bores will be decommissioned in accordance with the minimum construction requirements for water bores in Australia (DNRME, 2003) after the dam wall foundations are in place.

The groundwater discharge from the bores will be pumped to a sedimentation pond on the left bank of the river. The water retained in sedimentation ponds is to be re-used on the construction site where possible, or progressively released into the river under a water quality management plan. This water can also be used for irrigation of the GAB springs around the dam construction area if required during construction.

The impacts of dewatering on river flow and water quality are assessed in Chapter 14 and Chapter 15 respectively. Potential impacts on groundwater and groundwater dependent ecosystems can be found in Section 28.4.2.

28.2.4.3. Dam foundation preparation

Excavation of the dam foundation will remove any unsuitable material and is anticipated to range in depth from one metre up to about 5 m. Following excavation to the foundation level, the exposed foundation will be compacted.

28.2.4.4. Dam wall construction

In general terms the placement method for the E&R dam involves spreading and compacting of the earthfill in layers along the axis of the dam. The E&R dam will be protected from overtopping during construction by roller compacted concrete installed on the downstream face of the rockfill.

28.2.4.5. Dam construction sequence

The construction sequence for the E&R dam is primarily determined by the strategy adopted to manage river flow including flooding during construction. The proposed construction sequence is described below (not necessarily listed in the order in which they will be undertaken):

- excavating a channel within the right abutment to be used for flow diversion;
- constructing coffer dams, at either end of the flow diversion channel, to store water upstream and safely divert flows through the channel, to catch site runoff downstream for treatment or use and to prevent backflow of diverted water from downstream (note that the dimensions of the coffer dam may be varied to optimise the construction program);
- making provision for safety and site stability in the event the upstream coffer dam is over-topped and the site is flooded;
- establishing temporary surface drainage, erosion protection and ongoing water quality management across the site through measures such as:
    - design of work areas to minimise exposure of unprotected soil to rainfall and minimise slopes on drains;
    - temporary runoff barriers;
    - sedimentation ponds; and
    - progressive rehabilitation as work stages are completed;
- excavating foundations until suitable foundation is encountered and stockpiling soil materials for use in rehabilitation;
- dewatering and cleaning foundations using air or water and collecting and recycling any water used;
- completing final design and producing 'for construction' drawings;
- constructing the intake tower;
- placing concrete foundation material with rock anchor bars where required;
- completing fish transfer system works;
- blasting and excavating the spillway and spillway exit channel and stockpiling soil materials for use in rehabilitation;
- constructing the spillway crest, plunge pool and outlet channel with anchor bars as required and concrete protection as necessary;
- excavating clay materials and importing any sandy materials required and any additional rockfill not sourced from the spillway works;
- establishing the embankment drainage system;

- placing core, rockfill, filter and rip rap materials concurrently with compaction and reinforcement as required and reinforcement on the downstream face;
- completing the embankment crest to include any road pavement required;
- completing the inlet tower, bridge, valve system, valve house, dissipater system and the flume to existing stream channel;
- completing the embankment drainage system with leakage monitoring and outlets as required;
- converting the diversion conduit to function as the outlet conduit and decommissioning the coffer dams;
- providing erosion protection on the stream banks in the vicinity of the spillway outfall;
- constructing permanent access tracks with locked gated for operations and maintenance;
- constructing facilities required for public access including measures to restrict public access to hazardous areas and to ensure public safety generally;
- completing the permanent surface drainage system with appropriate erosion and outfall protection;
- decommissioning the site offices, storage and maintenance area with appropriate treatment or disposal of any contaminated soil or materials; and
- completing site rehabilitation works including re-shaping and re-vegetating areas where materials have been stockpiled or extracted and all other disturbed areas.

28.2.4.6. Disruption to flows during construction and diversion works

The construction sequence is such that no interruption to natural flows of the Dawson River will occur prior to closure of the dam at the commencement of storage. After that time the outlet works will be operated to meet all riparian and environmental flows requirements. No water can be released below dead storage (34,502 ML) but this is likely to be a rare occurrence. The mean monthly flow at Nathan Gorge ranges from 6171 ML to 223,818 ML, though zero flow has been recorded in most months. It is considered very likely that the minimum operating level of the outlet works and fishway would be reached within the first year of operation. This is further discussed in Chapter14 along with a first filling strategy.

During construction, all flood events will have to be either passed around the works or safely through the works. The E&R style of dam will allow for safe overtopping by major flood waters during construction when protected by concrete on the downstream face with minimal risk of damage to the construction works. Likewise the coffer dams, which will not be referable dams, will be protected on the downstream face with gabions.

28.2.4.7. Erosion control and stormwater / water quality management

As a means of reducing surface runoff following rain, areas of disturbance will be isolated with silt fencing that is supported by a defined maintenance system throughout the duration of the Project. A large sediment pond is anticipated on the left bank upstream of the dam wall. A detailed sediment erosion and control plan will be established by the construction contractor in accordance with the EMP outlined in Chapter 29.

All stockpiles will be similarly protected and areas of disturbance stabilised by grassing where appropriate.

To prevent the loss of silts and clays to the river downstream a series of floating booms supporting silt curtains weighted to the river bed may be installed isolating the areas of activity.

These screens will be installed prior to any disturbances to the river banks and be maintained on a daily basis. They will need to be removed prior to any substantial flow event.

28.2.5. Pipeline construction

28.2.5.1. Construction activities

It is envisaged that the pipeline will be laid simultaneously on four work fronts. There will also be dedicated teams undertaking:

- construction of each of the balancing storages;
- vegetation clearing in advance of pipe laying;
- river/ creek crossings;
- general pipeline fittings; and
- electrical and mechanical fit-out.

Upon completion of the construction, the integrity of the pipeline will be tested by hydrostatic testing crews and finally commissioned by another crew.

28.2.5.2. Construction methodology

Each pipe laying workfront would only open as much trench per day as could be laid in a day, with trench backfilling occurring simultaneously to ensure minimal open trench remains at any given time. Any open trench will be temporarily fenced at the end of each day.

Pipe laying will commence following site establishment, access track formation and easement clearing and includes:

- stripping of topsoil and stockpiling for subsequent rehabilitation;
- excavation of a benched trench, spoil is placed in a pile to the side of the trench;
- 150 mm layer of bedding material placed on the base of the trench;
- pipe is laid and Cathodic Protection added (connected to lugs). Any additional welding or grouting is performed;
- bedding material is filled to at least 150 mm above pipe and compacted;
- conduit and /or Fibre Optic Cable (FOC) is connected and laid just off pipe centreline;
- warning tape laid over FOC and pipeline;
- backfilling using excavated material which is then compacted;
- excess spoil is mounded (with appropriate gaps to allow for water movement) or used in erosion rehabilitation;
- reinstatement of topsoil for rehabilitation works; and
- any reinstatement or additional works are performed, i.e. installation of communication pits, etc.

It is estimated that for a 1200ND pipe, up to 1 km could be laid in a day on each front, with up to approximately 500 m of open trench at each front at any given time.

28.2.5.3. Creek crossings

Watercourses along the route flow intermittently and, as works in these areas are programmed for the dry period of the year, it is expected that most creeks will be dry at the time of construction. The preferred crossing method is by trench with the width of clearing of the riparian zone minimised as much as possible. The trench may need to be shored to ensure safe working conditions and temporary work platforms for machinery may be necessary. Depth of the trench will be such that the pipe will be below the level of flood scour.

At the crossing of larger watercourses that contain permanent water, the trench area will be isolated by coffer dams constructed from excavated material from either the pipeline trench or imported material. The coffer dams will be stabilised with sandbags and/or geotextile fabric. Depending on the stability and porosity of material in the stream bed sheet piling may be used to provide stability to the coffer dams. Fish and other aquatic wildlife enclosed by the coffer dams will be salvaged in accordance with DPI's Fish Salvage Guidelines (DPI&F, 2004). It may be necessary to dewater the trench using pumps and discharge the water downstream. A secondary low level coffer dam may need to be constructed to act as a sediment basin depending on the environment downstream and the suspended sediment concentration of the discharge water.

In most stream beds the pipeline will be encased in concrete. It is not essential that the trench be fully dewatered in order to place the concrete, which can be achieved under water.

On completion of works the coffer dams will be removed slowly and the stream bed and banks reinstated to their original profile. Excavated trench material will be replaced in the vertical order in which it was removed if any stratification of material is evident.

Pipeline construction is programmed begin in 2014 (following early works) and take one and half to two years to complete.

28.2.5.4. Pump stations and balancing storages

Construction works for the pump stations will include:

- site preparation involving vegetation clearing and excavation of earth to create a level working area;
- placement of concrete and sheet pile foundations;
- construction of pump housing structure;
- installation of the pumps and pipe work;
- connection to the upgraded electric power supply;
- fitting and testing the control system; and
- removal of temporary facilities and revegetation of disturbed areas.

The pump station and balancing ponds construction sites will be securely fenced.

Construction processes for the balancing storages (concrete tanks) and other above ground infrastructure are generally similar and include:

- vegetation clearing and excavation works to clear area for construction;

- concrete foundations and trenching for installation of inlet and outlet pipe works;
- formwork;
- reinforcing steel and concrete pouring and stressing;
- hauling and craning valves and fittings;
- installation of automated sensor equipment;
- hydrostatic testing of tank; and
- reinstatement and rehabilitation of disturbed areas.

Construction of the 600 ML earth tank will involve:

- vegetation clearing and site establishment;
- earthworks including excavation of natural ground and mounding of tank walls (overburden to provide material for storage walls);
- installation of pipe work, valves and pits for inlet and outlet piping;
- hauling materials and compaction along tank walls;
- geofabric / clay lining installation;
- installation of automated sensory equipment; and
- reinstatement works to disturbed areas including placement of topsoil and spraying of hydro-mulch.

28.2.5.5. Erosion control and stormwater / water quality management

Construction spoil stockpiles will be minimised by backfilling and mounding of the pipeline trench as the work progresses. As discussed previously, excess spoil will be mounded over the trench in a low mound with appropriate gaps to allow for water movement. Excess spoil stockpiles waiting backfill/mounding will be contained at the end of each day by temporary sediment control devices (e.g. silt fences). The temporary erosion and sediment control measures will be put in place to ensure that soil or sediment does not leave the area, and turbid water does not flow into drainage lines or creeks. Upon completion of topsoiling and profiling, areas disturbed by the works will be revegetated. The revegetated areas will be kept moist until germination has been obtained and thereafter as required to establish appropriate cover.

28.2.5.6. Vegetation clearing and fauna relocation

Construction of the pipeline will require clearing within a 30 m wide easement including access tracks. This is the maximum easement width required for construction but depending on terrain and adjacent land use it may be possible to reduce this where there is space available for machinery access (i.e. adjacent to roads or at creek crossings), where significant REs and threatened ecological communities occur.

Approval for clearing is as per the dam and the mitigation measures will be incorporated into a clearing plan.

28.2.6. Operation

28.2.6.1. Water storage infrastructure

The objectives for the operation of the water storage are to:

- divert 66,011 ML/a of high priority or equivalent water via a pipeline and downstream distribution to existing and new users;
- minimise upstream impacts of floods;
- safely pass flood flows such that the integrity of the dam is not compromised;
- meet the requirements specified in the Fitzroy Basin Water Resource Plan (DNRW, 1999) (WRP) including environmental flow requirements;
- provide for effective movement of aquatic fauna past the dam;
- minimise environmental degradation in and around the storage and downstream; and
- minimise community impacts in the areas around the storage and downstream.

The water storage will be available for recreational use.

28.2.6.2. Water distribution pipeline

The pipeline will generally operate automatically. Water level sensors in each balancing storage will detect a drop in water level in the storage and cause the preceding pump station to start automatically. This automation ensures that the pumps start and stop in the correct start-up sequence to prevent excessively high or low hydraulic pressures within the system. In the event of a system or pump station failure, an alarm is sent to the operator who will respond accordingly.

Regular monitoring of the pipeline will be required to ensure:

- detection of minor leaks;
- effectiveness of landscape shaping, revegetation and weed control;
- valves and sensors are functioning;
- above ground infrastructure is maintained in a safe and secure condition; and
- efficiency of water flow.

Leaks are generally detected by manual inspection and operator experience. If significant, they may also be inferred by the control system by a gross water balance, e.g. by detecting that the pumps are operating but, when accounting for the outflows, the storage levels are not changing at the expected rate. The location and severity of any detected leak influences how it is treated. A major break spilling a large quantity of water with a high potential for damage would require as rapid a shutdown as possible. More minor leaks may be scheduled to be addressed at a convenient time. The emergency shutdown sequences will be described in the system manual produced for handover at commissioning. Typically lines are not completely drained for repairing leaks. If the leak is high up in the profile, lower sections of the pipeline will remain full of water during the repair process.

Regular maintenance will be required to lubricate pumps and associated infrastructure and to slash grass in areas at risk of damage from fire.

28.2.7. Consequential actions and cumulative impacts

28.2.7.1. Relationship with other projects

The EPBC Act definition of impact includes both direct and indirect consequences of an action. An indirect consequence can result from actions taken by a second person whether or not these actions were taken at the direction of the person who took the primary action. The primary action must, to a major extent, facilitate the secondary action.

The Project is related to other water infrastructure projects that are part of the Central Queensland Regional Water Supply Strategy (CQRWSS) or the Statewide Water Policy (SWP) with respect to the role each piece of infrastructure has in servicing the region. These include:

- Connors River Dam and Pipelines;
- Lower Fitzroy River Infrastructure Project including construction of Rookwood Weir and raising Eden Bann Weir; and
- Gladstone – Fitzroy Pipeline.

Each of these projects is at different approvals phases and requires a full business case to be developed and approved before they can proceed. It is not assured that all these projects will progress to construction. These projects are not considered secondary impacts or consequential actions in accordance with section 527E of the EPBC Act because they are independent projects that would progress through the approvals process irrespective of the Nathan Dam Project. Without Nathan Dam these projects would still proceed in order to meet demands in their respective sub-regions.

The Coordinator General and the Commonwealth Minister have recently recommended that the Xstrata Wandoan Coal Project (WCP) be approved. The WCP included an option to raise Glebe Weir and a pipeline from Glebe Weir to provide part of the mine's water supply. Regardless of whether the Glebe Weir Raising goes ahead, Nathan Dam will replace Glebe Weir within the Dawson Valley Water Supply Scheme. There is a possibility that SunWater will need to construct two pipelines along the northern section of the pipeline alignment; the Glebe Weir to WCP pipeline and the Nathan Pipeline. The need for two pipelines stems from the timing of the two projects, with Xstrata requiring a water supply in 2013 when the Nathan project would only be commencing construction, should it be approved. However it is SunWater's preference to amalgamate the two pipelines if possible, and as both projects proceed and their approval and construction timeframes become certain, every effort will be made to proceed with a single pipeline.

A range of resource development and infrastructure projects are currently operating, or are planned within the wider region and along the pipeline route.

Existing projects include:

- Wilkie Creek Mine, Peabody Energy - 2.35 million tonnes per annum (Mtpa) thermal coal mine, 45 km north-west of Dalby and 250 km rail line to the Port of Brisbane;
- Darling Downs Power Station Project, Origin Energy – 630 MW gas fired power station located at Braemer, 40 km west of Dalby; and
- Kogan Creek Power Station, CS Energy Ltd – 750 MW coal fired power station approximately 35 km from Chinchilla Linked to the Kogan Creek Mine, supplying 2.8 Mtpa of coal.

Planned projects include:

- Wandoan Coal Project, Xstrata Coal Queensland Pty Ltd - Open cut coal mine producing 20 Mtpa, located directly west of Wandoan ;
- Surat Basin Railway Southern Missing Link, Surat Basin Rail Joint Venture – 210 km railway joining the Surat Basin (at Wandoan) to the Moura Railway system near the township of Banana, facilitating the export of coal to the Port of Gladstone (not a controlled action and the Coordinator Generals report on the Project has been released);
- Queensland Curtis LNG Project, Queensland Gas Company - Integrated LNG project comprising expansion of Coal Seam Gas (CSG) operations in Western Downs RC (primarily west of Chinchilla), and the development of a 380 km gas pipeline to Gladstone, transecting through Taroom and Banana Shire Council;
- Gladstone LNG Project, Santos - Integrated LNG project comprising expansion of CSG operations near the townships of Roma and Injune, and the development of a 435 km transmission pipeline to an LNG Facility in Gladstone, passing through the Banana Shire Council area;
- Surat Gas Project, Arrow Energy Ltd - The Project proposes to develop a major coal seam gas exploration, development and production project near the townships of Chinchilla, Dalby and Wandoan and the development of a 467 km transmission pipeline to Arrow Energy Ltd Curtis Island Project, starting in Western Downs Regional Council and traversing through Banana Shire Council; and
- Australia Pacific LNG (APLNG) CSG Project - Construction of a 450 km gas transmission pipeline from the coal seam gas fields in Surat basin to an LNG plant at Gladstone, and development of the LNG plant which will have a processing capacity of up to 18 Mtpa.

The Project is relevant to coal mining projects because coal mining generates a large proportion of the demand for additional water. There are numerous mines at various stages of development or assessment in the region. It is expected that if and when particular mines develop, the proponent for the mine will assess the water needs and the supply options available to it. The existence of the stored water in Nathan Dam and the potential access to the trunk pipeline will form part of that assessment. Any mines, or other potential sources of demand, which choose this supply option, will require approvals. Those approvals will be based on assessment of the impacts of their water use and waste water disposal. This would also include any necessary further delivery infrastructure, such as lateral pipelines joining the trunk pipeline to the specific demand node.

28.2.7.2. Consequential actions

The primary action in this case is the construction and operation of the Nathan Dam and Pipeline project. Indirect consequences can relate to secondary actions taken by secondary persons or to secondary actions not being undertaken at the direction of the primary person, being SunWater. In order to identify such secondary actions SunWater has:

- reviewed the potential users or user groups of water from the Project;
- estimated the actions (potential secondary actions) that each user group may take as a result of the supply of water from the Project; and
- considered whether the supply of water facilitates to a major extent the secondary action.

As described in Section 1.4, coal mining generates the majority of the demand for water from the Project. Demand for agricultural use is limited by the likely cost of supply of the water and therefore it is not anticipated that the Project will

facilitate expansion of agriculture. Urban demand is a small component of overall demand and is not specifically included in the Project. Urban water may be accessed from the pipeline based on commercial arrangements, similar to those for any other user.

Section 1.4 noted that SunWater does not accept there are any relevant "events or circumstances" that will arise from mining activities which may take water from Nathan Dam because:

In terms of section 527E of the EPBC Act:

- the primary action (in this case the dam) cannot be said to facilitate to a major extent any particular secondary action (i.e. mining activity). This is because the mining industry has other sources of water available to it and SunWater expects that if Nathan Dam did not proceed, water for any particular mining project could be sourced elsewhere; and
- if however a relevant secondary action could be said to be facilitated to a major extent by Nathan Dam then any relevant "event or circumstance" likely to have a significant impact on the relevant Matter of National Environmental Significance (MNES; e.g. World Heritage), and which may be a consequence of the secondary action, is definitely not within the contemplation of SunWater (the primary person), nor is such a relevant event or circumstance, whatever it might be, a reasonable consequence of the secondary action.

In terms of the SEWPaC Guidelines on this issue:

- to the extent that there may be any relevant indirect impacts (associated with mining activities) such impacts (if any) would occur irrespective of the proposed action, i.e. mining projects would continue to be developed irrespective of the Nathan Dam Project;
- the proposed action cannot be said to be a material and substantial cause of any indirect impacts. If there are any such impacts they would be a direct consequence of the mining activity which would exist in any event; and
- there are no relevant potential impacts of any possible third party actions (mining activities) known to SunWater or that could be expected to be known to SunWater.

However, notwithstanding the above position SunWater is prepared to provide such information as it has been able to gather in relation to mining projects generally in the region which may or may not generate impacts (events or circumstances). SunWater has also reviewed recent coal industry related EIS's in the region to determine their controlled action status hence their likelihood of impact on MNES. The list below was generated from the SEWPaC website and relates to recent mining projects in the region.

The following projects are in the Fitzroy catchment and were determined as controlled actions with respect to listed threatened species and communities only. They were not a controlled action with respect to World Heritage, National Heritage places, wetlands of international importance, listed migratory species or Commonwealth marine areas:

- Xstrata Rolleston Open Cut Coal Mine Expansion;
- Wandoan Joint Venture Wandoan Coal Project;
- Anglo Coal Foxleigh Coal Mine Extension;
- Aquila Resources Washpool Coal Mine Project;
- BM Alliance Daunia Open Cut Coal Mine Project; and

- BM Alliance Norwich Park East Pit.

The North Goonyella Coal Co-disposal facility in the Connors River catchment was determined to not be a controlled action. The Cows Coal Project proposed by Bowen River Coal was not declared a controlled action (Bowen River is a reef catchment). The Surat Basin Rail Project was not a controlled action. Several of these actions and many in addition, have gone on to be approved. SunWater would only provide water to a mine which had been approved and as a likely consequence, where matters of NES has been considered.

Based on detailed consideration (Section 1.4) of potential users of water from the Project and the foreseeable secondary actions arising from the Project, it is concluded that the Project:

- does not facilitate to a major extent coal mining activities (as discussed above),
- does not facilitate to a major extent urban growth; and
- does not facilitate to a major extent agricultural activity.

An assessment of the consequential and cumulative impacts of the Project is provided in Chapter 27. Cumulative impacts of the Project on matters of NES are discussed in Section 28.6.

28.3. Description of the affected environment

28.3.1. World Heritage properties

The Great Barrier Reef World Heritage Area (GBRWHA) may be affected by the Project, as determined by the Commonwealth government in its assessment of the likely impact of the Project on MNES. The Fitzroy River Basin discharges into the GBRWHA at Keppel Bay, south-east of Rockhampton, about 620 km downstream of the Project. A desktop assessment was undertaken to determine the actual or likely impact on the values of the GBRWHA. The literature reviewed and analysed in the desktop assessment includes data derived from database searches, information held by agencies/ individuals and interpretive reports.

SEWPaC provided the basis for the majority of background information regarding the values of the GBRWHA. The Great Barrier Reef was inscribed on the World Heritage List in 1981. The World Heritage criteria against which the Great Barrier Reef was listed remain the formal criteria for this property and are described in Table 28-6.

Table 28-6 World Heritage criteria for the Great Barrier Reef

Outstanding example representing a major stage of the earth's evolutionary history.
The Great Barrier Reef is by far the largest single collection of coral reefs in the world. The World Heritage values of the property include: ▪ 2904 coral reefs covering approximately 20,055 km squared; ▪ 300 coral cays and 600 continental islands; ▪ reef morphologies reflecting historical and on-going geomorphic and oceanographic processes; ▪ processes of geological evolution linking islands, cays, reefs and changing sea levels, together with sand barriers, deltaic and associated sand dunes; ▪ record of sea level changes and the complete history of the reef's evolution are recorded in the reef structure; ▪ record of climate history, environmental conditions and processes extending back over several hundred years within old massive corals; ▪ formations such as serpentine rocks of South Percy island, intact and active dune systems, undisturbed tidal sediments and "blue holes"; and

- record of sea level changes reflected in distribution of continental island flora and fauna.

Outstanding example representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment.

Biologically the Great Barrier Reef supports the most diverse ecosystem known to man and its enormous diversity is thought to reflect the maturity of an ecosystem, which has evolved over millions of years on the northeast Continental Shelf of Australia. The World Heritage values include:

- the heterogeneity and interconnectivity of the reef assemblage;
- size and morphological diversity (elevation ranging from the sea bed to 1142 m at Mt Bowen and a large cross-shelf extent encompass the fullest possible representation of marine environmental processes);
- ongoing processes of accretion and erosion of coral reefs, sand banks and coral cays, erosion and deposition processes along the coastline, river deltas and estuaries and continental islands;
- extensive Halimeda beds representing active calcification and sediment accretion for over 10 000 years;
- evidence of the dispersion and evolution of hard corals and associated flora and fauna from the "Indo-West Pacific centre of diversity" along the north-south extent of the reef;
- inter-connections with the Wet Tropics via the coastal interface and Lord Howe Island via the East Australia current;
- indigenous temperate species derived from tropical species;
- living coral colonies (including some of the world's oldest);
- inshore coral communities of southern reefs;
- five floristic regions identified for continental islands and two for coral cays;
- the diversity of flora and fauna, including:
- Macroalgae (estimated 400-500 species);
- Porifera (estimated 1500 species, some endemic, mostly undescribed);
- Cnidaria: Corals - part of the global centre of coral diversity and including:
- hexacorals (70 genera and 350 species, including 10 endemic species);
- octocorals (80 genera, number of species not yet estimated);
- Tunicata: Ascidians (at least 330 species);
- Bryozoa (an estimated 300-500 species, many undescribed);
- Crustacea (at least 1330 species from three subclasses);
- Worms;
- Polychaetes (estimated 500 species);
- Platyhelminthes: include free-living Tubelleria (number of species not yet estimated), polyclad Tubelleria (up to 300 species) and parasitic helminthes (estimated 1000's of species, most undescribed);
- Phytoplankton (a diverse group existing in two broad communities);
- Mollusca (between 5000-8000 species);
- Echinodermata (estimated 800 extant species, including many rare taxa and type specimens);
- fishes (between 1200 and 2000 species from 130 families, with high species diversity and heterogeneity; includes the Whale Shark Rhynchodon typus);
- seabirds (between 1.4 and 1.7 million seabirds breeding on islands);
- marine reptiles (including 6 sea turtle species, 17 sea snake species, and 1 species of crocodile);
- marine mammals (including 1 species of dugong (Dugong dugon), and 26 species of whales and dolphins);
- terrestrial flora: see "Habitats: Islands" and;
- terrestrial fauna, including:
- invertebrates (pseudoscorpions, mites, ticks, spiders, centipedes, isopods, phalangids, millipedes, collembolans and 109 families of insects from 20 orders, and large over-wintering aggregations of butterflies); and
- vertebrates (including seabirds (see above), reptiles: crocodiles and turtles, nine snakes and 31 lizards, mammals);
- the integrity of the inter-connections between reef and island networks in terms of dispersion, recruitment, and the subsequent gene flow of many taxa;
- processes of dispersal, colonisation and establishment of plant communities within the context of island biogeography (e.g. dispersal of seeds by air, sea and vectors such as birds are examples of dispersion, colonisation and succession);
- the isolation of certain island populations (e.g. recent speciation evident in two subspecies of the butterfly Tirumala hamata and the evolution of distinct races of the bird Zosterops spp);
- remnant vegetation types (hoop pines) and relic species (sponges) on islands.

- evidence of morphological and genetic changes in mangrove and seagrass flora across regional scales; and
- feeding and/or breeding grounds for international migratory seabirds, cetaceans and sea turtles.

Contain unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty.

- The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty. The World Heritage values include:
- the vast extent of the reef and island systems which produces an unparalleled aerial vista;
- islands ranging from towering forested continental islands complete with freshwater streams, to small coral cays with rainforest and unvegetated sand cays;
- coastal and adjacent islands with mangrove systems of exceptional beauty;
- the rich variety of landscapes and seascapes including rugged mountains with dense and diverse vegetation and adjacent fringing reefs;
- the abundance and diversity of shape, size and colour of marine fauna and flora in the coral reefs;
- spectacular breeding colonies of seabirds and great aggregations of over-wintering butterflies; and
- migrating whales, dolphins, dugong, whale sharks, sea turtles, seabirds and concentrations of large fish.

Provide habitats where populations of rare and endangered species of plants and animals still survive.

The Great Barrier Reef contains many outstanding examples of important and significant natural habitats for in situ conservation of species of conservation significance, particularly resulting from the latitudinal and cross-shelf completeness of the region. The World Heritage values include:

- habitats for species of conservation significance within the 77 broad-scale bioregional associations that have been identified for the property and which include:
- over 2900 coral reefs (covering 20 055 km^2) which are structurally and ecologically complex;
- large numbers of islands, including:
- 600 continental islands supporting 2195 plant species in 5 distinct floristic regions;
- 300 coral cays and sand cays;
- seabird and sea turtle rookeries, including breeding populations of green sea turtles and Hawksbill turtles; and
- coral cays with 300-350 plant species in two distinct floristic regions;
- seagrass beds (over 5000 km squared) comprising 15 species, 2 endemic;
- mangroves (over 2070 km squared) including 37 species;
- Halimeda banks in the northern region and the unique deep water bed in the central region; and
- large areas of ecologically complex inter-reefal and lagoonal benthos; and
- species of plants and animals of conservation significance.

(SEWPaC, 2010)

28.3.2. National Heritage places

The Great Barrier Reef is also listed as a National Heritage Place on the National Heritage List. The National Heritage List has been established to list places of outstanding heritage significance to Australia. It includes natural, historic and Indigenous places that are of outstanding national heritage value to the Australian nation.

A desktop assessment was undertaken to determine the actual or likely impact on the National Heritage Place. The literature reviewed and analysed in the desktop assessment includes data derived from database searches, information held by agencies/ individuals and interpretive reports.

A search of the Register of the National Estate provided the basis for the majority of background information regarding the values of the Great Barrier Reef. The summary statement of significance for the Great Barrier Reef National Heritage Place states the following (DEH, unknown):

> *"The Great Barrier Reef, one of Australia's first World Heritage Areas, was inscribed on the World Heritage List in recognition of its outstanding natural universal values:*

- *as an outstanding example representing the major stages in the earth's evolutionary history;*
- *as an outstanding example representing significant ongoing ecological and biological processes;*
- *as an example of superlative natural phenomena; and*
- *containing important and significant habitats for in situ conservation of biological diversity.*

It is the world's largest World Heritage Area extending 2 000 kilometres and covering an area of 35 million hectares on the north-east continental shelf of Australia. Bigger than the entire area of Italy, it is probably the best known marine protected area in the world. The Great Barrier Reef's great diversity reflects the maturity of the ecosystem, which has evolved over hundreds of thousands of years. It is the world's most extensive coral reef system and is one of the world's richest areas in terms of faunal diversity.

The Great Barrier Reef World Heritage Area contains more than just coral reefs. It also contains extensive areas of seagrass, mangrove, soft bottom communities and island communities. Contrary to popular belief, the reef is not a continuous barrier, but a broken maze of coral reefs and coral cays. It includes some 2 800 individual reefs, of which 760 are fringing reefs. These reefs range in size from less than one hectare to more than 100 000 hectares, and in shape from flat platform reefs to elongated ribbon reefs.

The Great Barrier Reef provides habitats for many diverse forms of marine life. There are an estimated 1 500 species of fish and more than 300 species of hard, reef-building corals. More than 4 000 mollusc species and over 400 species of sponges have been identified.

Other well-represented animal groups include anemones, marine worms, crustaceans (prawns, crabs etc.) and echinoderms (starfish, sea urchins etc.).

The extensive seagrass beds are an important feeding ground for the dugong, a mammal species internationally listed as endangered.

The reef also supports a wide variety of fleshy algae that are heavily grazed by turtles, fish, sea urchins and molluscs.

The reef contains nesting grounds of world significance for the endangered green and loggerhead turtles. It is also a breeding area for humpback whales, which come from the Antarctic to give birth to their young in the warm waters.

The islands and cays support several hundred bird species, many of which have breeding colonies there. Reef herons, osprey, pelicans, frigate birds, sea eagles and shearwaters are among the numerous sea birds that have been recorded.

The World Heritage property is also of cultural importance, containing many middens and other archaeological sites of Aboriginal or Torres Strait Islander origin. Some notable examples occur on Lizard and Hinchinbrook Islands, and on Stanley, Cliff and Clack Islands where there are spectacular galleries of rock paintings.

There are over 30 historic shipwrecks in the area, and on the islands are ruins and operating lighthouses that are of cultural and historical significance.

About 98 per cent of the World Heritage Property is within the Great Barrier Reef Marine Park, the remainder being Queensland waters and islands. The Great Barrier Reef Marine Park was declared in 1975 with the purpose of preserving the area's outstanding biodiversity whilst providing for reasonable use. This has been achieved using a spectrum of zones ranging from General Use Zones to Preservation Zones. In very broad terms, these zones allow ecologically sustainable activities, but all have an overriding conservation objective. Most reasonable activities such as tourism, fishing, boating, diving and research are permitted to occur but are controlled through zoning and management planning to minimise impacts and conflicts with areas of high conservation value and other users.

Today, the great majority of the Marine Park is still relatively pristine when compared with coral reef systems elsewhere in the world. An independent report published in 1997 concluded that the Reef is in good condition and is being managed effectively."

28.3.3. Wetlands of International Importance

The Shoalwater and Corio Bays Area are Wetlands of International Importance that may be impacted by the Project, as determined by the Commonwealth government in its assessment of the likely impact of the Project on MNES. A desktop assessment was undertaken to determine the actual or likely impact on the Wetlands of International Importance. Literature reviewed and analysed in the desktop assessment includes data derived from database searches, information held by agencies/ individuals and interpretive reports. A search of the Australian Wetlands Database provided the basis for the majority of background information regarding the Shoalwater and Corio Bays Area.

The Shoalwater and Corio Bays Area is located in the Rockhampton Regional Council LGA. The southern boundary is approximately 50 km north of Rockhampton. As stated in Section 28.3.1 the Project lies within the catchment of the Fitzroy River, which discharges into Keppel Bay 100 km to the south of the Shoalwater and Corio Bays Area.

The Shoalwater and Corio Bays area is bounded by approximately 330 km of coastline including islands. The area represents a climatic overlap zone with an unusual mix of tropical, sub-tropical and temperate species. The area also represents the largest wilderness area within the Central Mackay Coast biogeographic area and on the central Queensland coast.

The Shoalwater and Corio Bays Area (Shoalwater Bay Training Area, in part - Corio Bay) Ramsar site meets six of the nine criteria and are described below:

- Criterion 1: The Shoalwater and Corio Bays Area Ramsar site is in the North-east Coast Australian Drainage Division. It contains the largest area in central east Queensland of representative coastal, subcoastal and aquatic landscapes and ecosystems in a relatively undisturbed state. The area represents one of a very few large estuarine systems that retains a relatively undisturbed catchment;
- Criterion 2: The Shoalwater and Corio Bays Area Ramsar site supports populations of the threatened Green Turtle, Flatback Turtle and Hawksbill Turtle and the endangered Loggerhead Turtle. The site also supports the EPBC Act listed Dugong;

- Criterion 3: The Shoalwater and Corio Bays Area contain a high diversity of freshwater, marine and estuarine fish species, with 445 species recorded. Eighteen species of mangroves occur in the area. There are at least 10 species of seagrass present, with seagrass beds extending to depths of 20 m due to water clarity. The site is of special value as habitat for endemic fish species. The mangrove, tidal mudflats and saltflats are important habitats for local and migratory shorebirds, including 26 species protected under international migratory bird conservation agreements;
- Criterion 4: This Ramsar site provides nesting sites for turtles and critical feeding areas for turtles and Dugongs. It also provides breeding sites for the Beach Stone-Curlew;
- Criterion 5: The Shoalwater and Corio Bays Area Ramsar site supports over 20,000 waterbirds in summer; and
- Criterion 6: Six species of migratory shorebirds have been recorded in the Shoalwater and Corio Bays Area Ramsar site at numbers exceeding 1% of their population in the East Asian Australasian Flyway, including the Eastern Curlew, Whimbrel and Great Knot.

28.3.4. Threatened species and ecological communities

The ToR for the Project included a list of potential listed threatened species and ecological communities to be considered in the preparation of the EIS. This provisional list included the following:

- the community of native species dependent on natural discharge from the Great Artesian Basin — Endangered;
- Brigalow (*Acacia harpophylla* dominant and co-dominant) — Endangered;
- natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland – Critically Endangered;
- semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions — Endangered;
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland — Critically Endangered;
- Boggomoss Snail (*Adclarkia dawsonensis*) — Critically Endangered;
- Fitzroy River Turtle (*Rheodytes leukops*) — Vulnerable;
- Loggerhead Turtle (*Caretta caretta*) — Endangered;
- Green Turtle (*Chelonia mydas*) — Vulnerable;
- Hawksbill Turtle (*Eretmochelys imbricate*) — Vulnerable;
- Flatback Turtle (*Nataor depressus*) — Vulnerable;
- Ornamental Snake (*Denisonia maculata*) — Vulnerable;
- Dunmall's Snake (*Furina dunmalli*) — Vulnerable;
- Yakka Skink (*Egernia rugosa*) — Vulnerable;
- Brigalow Scaly-foot (*Paradelma orientalis*) — Vulnerable;
- Five-clawed Worm-skink (*Anomalopus mackayi*) — Vulnerable;
- Grassland Earless Dragon (*Tympanocryptis pinguicolla*) — Endangered;
- Large-eared Pied Bat (*Chalinolobus dwyeri*) — Vulnerable;
- Water Mouse (*Xeromys myoides*) — Vulnerable;

- Northern Quoll (*Dasyurus hallucatus*) — Endangered;
- Eastern Long-eared Bat (*Nyctophilus timoriensis*) south-eastern form — Vulnerable;
- Murray Cod (Maccullochella peelii peelii) — Vulnerable;
- Swift Parrot (*Lathamus discolour*) — Endangered;
- Red Goshawk (*Erythrotriorchis radiatus*) — Vulnerable;
- Black-breasted Button-quail (*Turnix melanogaster*) — Vulnerable;
- Star Finch (eastern), (*Neochmia ruficauda ruficauda*) — Endangered;
- Squatter Pigeon (*Geophaps scripta scripta*) — Vulnerable;
- Yellow Chat (Dawson) (*Epthianura crocea macgregori*) — Critically Endangered;
- Hairy-joint Grass (*Arthraxon hispidus*) — Vulnerable;
- Ooline (*Cadellia pentastylis*) — Vulnerable;
- Cadarga (*Commersonia* sp.) — Vulnerable;
- Tricolour Donkey-orchid (*Diuris tricolor*) — Vulnerable;
- Finger Panic Grass (*Digitaria porrecta*) — Vulnerable;
- King Blue-grass (*Dichanthium queenslandicum*) — Vulnerable;
- Acacia chinchillensis — Vulnerable;
- Curly-bark Wattle (*Acacia curranii*) — Vulnerable;
- Calytrix gurulmundensis — Vulnerable;
- Denhamia parvifolia — Vulnerable;
- Belson's Panic (*Homopholis belsonii*) — Vulnerable;
- Cobar Greenhood Orchid (*Pterostylis cobarensis*) — Vulnerable;
- Austral Cornflower (*Rhaponticum australis*) — Vulnerable;
- Austral Toadflax (*Thesium australe*) — Vulnerable; and
- Westringia parvifolia — Vulnerable.

28.3.4.1. Methodology

- Desktop analysis

Various desktop and field surveys were undertaken to determine the actual or likely occurrence of those species and ecological communities listed in the ToR as potentially affected by the Project as well as any others not identified in the ToR. The literature reviewed and analysed in the desktop assessment includes data derived from database searches, information held by government agencies, individuals and interpretive reports. A gap analysis was completed, as part of the desktop analysis to inform the design of field surveys.

Database searches provided the basis for the majority of background information regarding the presence and distribution of ecological communities, flora and fauna species, both significant and otherwise, that are known or are likely to occur within the Project area.

The databases and mapping sourced include:

- the EPBC Act Online Protected Matters Search database;
- the Queensland Herbarium's Herbrecs and Corveg databases;
  - Herbrecs: Records of vouchered specimens of vascular terrestrial flora species lodged at the Queensland Herbarium;
  - CORVEG: Provides the results of vegetation survey plots;
- the Queensland Department of Environment and Water Resources (DERM) Wildnet database;
- the DERM Regional Ecosystem (RE), Essential Habitat and Regrowth Vegetation mapping;
- Biodiversity Planning Assessments (BPA) for the Brigalow Belt South (BBS) bioregion (EPA, 2002);
- Springs of Queensland (Version 5.0) (Fensham & Fairfax, 2008);
- Queensland Museum's fauna database; and
- Birds Australia New Atlas database.

In addition, several literature sources were reviewed including previous flora and fauna studies of the study area.

For the dam study area, the following coordinates were used to define a rectangular search area for database interrogations:

- 25°32'16" S, 149°58'5" E;
- 25°39'29" S, 149°58'5" E;
- 25°39'29" S, 149°44'38" E; and
- 25°32'16" S, 149°44'38" E.

For the pipeline corridor, several point searches were conducted (including a radius of 5 km) along the alignment of the pipeline centred on any areas containing a high cover of remnant vegetation. The results of these searches were then combined with the results of the database searches for the dam study area to identify any species unique to the Project corridor.

The coordinates for each point search and nearest place name are listed below:

- 26° 25'43"S; 150° 03'20"E – Gurulmundi;
- 26° 35'47"S; 150° 09'47"E – between Dalwogan and Miles;
- 26° 39'55"S; 150° 16'47"E – west of Columboola; and
- 26° 42'21" S; 150° 32'30"E – Baking Board, west of Chinchilla.

For the purpose of vegetation mapping, SPOT 2.5 m Satellite Imagery (August, 2006) and 1:25,000 scale orthoimagery (Sunwater, 1994) was utilised to establish preliminary vegetation line work and polygon attribution. The line work was completed with reference to the available remnant and pre-clearing regional ecosystem mapping to assign anticipated regional ecosystems. Polygons of both remnant and regrowth vegetation were identified through aerial photographic review.

- Field surveys

- *Aquatic flora*

Two field surveys were conducted in the dam and surrounds study area (as defined in Chapter 12) to describe the aquatic flora present in the freshwater habitats that may be affected by the Project (encompassing sites upstream of, within, and downstream of the proposed water storage area): a pre-wet season survey (26 November to 3 December 2007) (Appendix 12A) and a post-wet season survey (17 June to 24 June 2008) (Appendix 12B).

For the pipeline study area, one field survey (in the post-wet season, 27 to 31 October 2008) was undertaken to describe the aquatic flora present in the freshwater habitats crossed by the pipeline route (Appendix 12D).

- *Aquatic fauna*

The same three field surveys (noted above) also collected data to describe the aquatic fauna present in the freshwater habitats that may be affected by the Project (Chapter 13).

Field surveys targeted fish, macro-crustaceans, invertebrates and turtles (Appendix 12A, 12B, 12C). Turtles were surveyed using large hoop-net baited turtle traps. The design of the traps was consistent with traps used by DERM's turtle research group (and by frc environmental on behalf of Fitzroy Water, lower in the Fitzroy catchment in September 2007). Traps were closely monitored to ensure turtles or other air-breathing species did not become entangled or trapped.

Turtles captured or observed were identified to species and a photographic record was kept. All work was carried out in accordance with valid ethics permits.

Turtles were occasionally captured by other techniques (fyke net or seine net) or observed and recorded outside traps.

Further targeted surveys for the Fitzroy River Turtle were undertaken in October 2008 (Ecowise), October 2010 (frc environmental), and Sept-October 2011 (Appendix 12-C, 13-B and C).

Sampling methods to capture turtles included:

- Dip netting;
- Seine netting;
- Snorkel (conditions permitting);
- evening spotlighting;
- Pole camera;
- Muddling; and
- Adhoc observations

The suite of methods employed was dependent on the conditions encountered at each site. A summary of the sampling methods and effort at each site is presented in (Appendix 12-C, 13-B and C) The focus of these surveys were to assess the presence, distribution and reproductive / nesting status of the Fitzroy River turtle in the Nathan Dam study area.

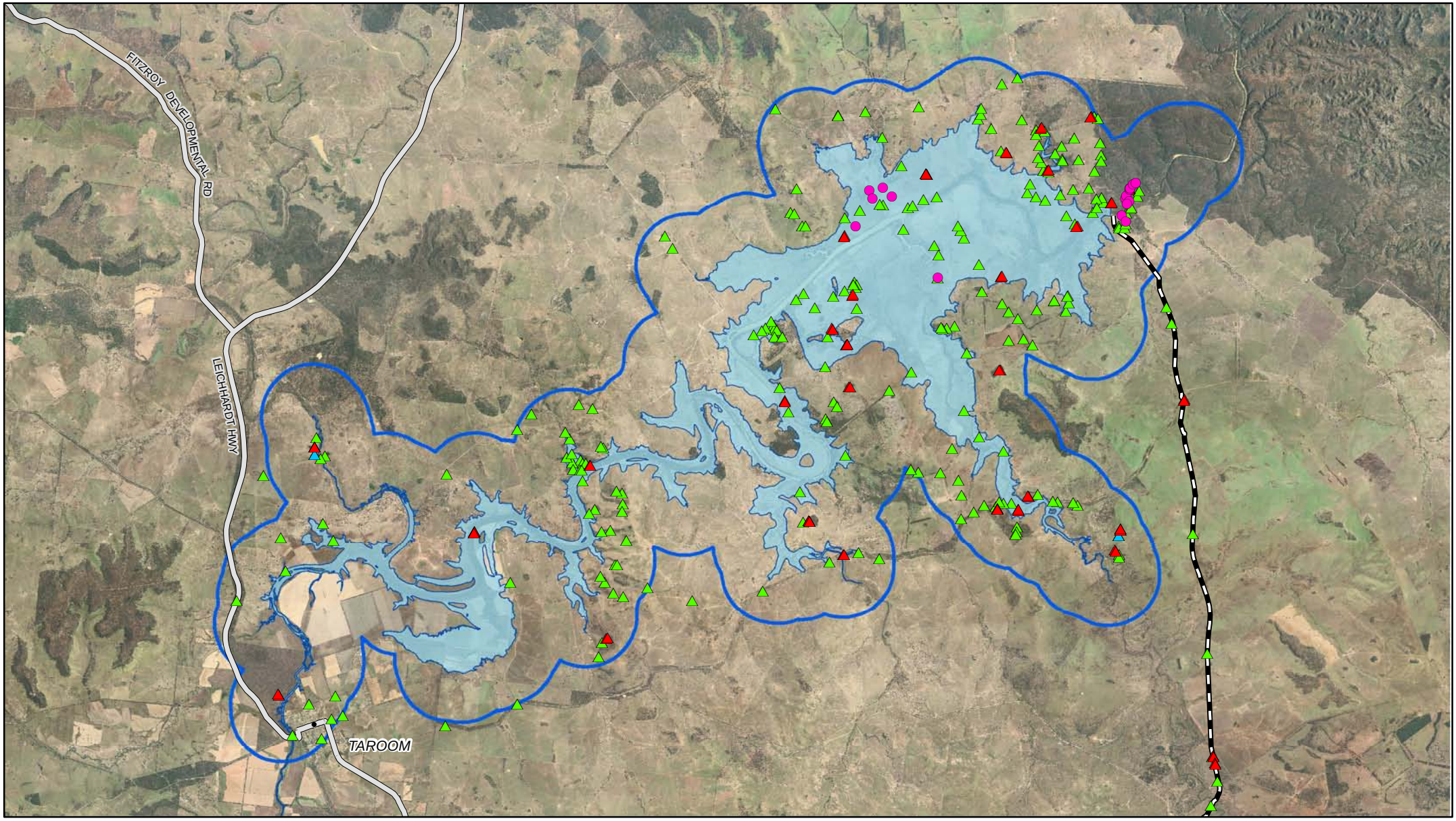
- *Terrestrial flora*

Vegetation was mapped at a scale of 1:10,000 as per the methodology developed by the Queensland Herbarium (Neldner *et al.*, 2005). The methods prescribed include a combination of secondary, tertiary and quaternary level sampling procedures. Additional informal site observations were also made. The mapping of vegetation categories across the entire study area was based on the regional ecosystem framework (Sattler & Williams, 1999). This is considered best practice in Queensland for the mapping of vegetation.

The field survey was completed by Chenoweth Environmental Planning and Landscape Architecture (CEPLA) in a number of phases to capture seasonal variation in floristics. Field surveys were undertaken in summer (26 March – 1 April, 2008), winter (12 June – 18 June, 2008), autumn (29 April, 6 May – 8 May 2008), spring (4 September – 5 September, 2008) and a second summer survey (1 December, 2008). This field work allowed for coverage of the entire Project area. Another survey (15 June - 22 June 2010) of the pipeline route was undertaken to incorporate changes to the route (Figure 28-3 and Figure 28-4).

Reference sites established in undisturbed or lightly disturbed vegetation communities within the vicinity of the Project area provide data to allow an assessment of the remnant/non-remnant status of a specific regional ecosystem against vegetation height, cover and floristics. The data also provides a reference point for the assessment of vegetation community condition.

GAB springs were previously mapped and described to a high standard (Fensham & Wilson, 1997; Fensham & Fairfax, 2005). The mapping of GAB spring locations was highly accurate with the exception of some springs located in Nathan Gorge. Through aerial photographic analysis and opportunistic observations during field surveys a number of additional springs were identified and the location of springs mapped by Fensham & Fairfax (2005) was refined.



LEGEND

- Towns
- Pipeline Route
- State Controlled Roads
- Full Supply Level (183.5m AHD)
- Dam Study Area

2008 CEPLA Survey Sites

- 2008 CEPLA Secondary Sites
- 2008 CEPLA Tertiary Sites
- 2008 CEPLA Quaternary Sites
- CEPLA Ground-truthed Boggomoss Sites

2010 CEPLA Survey Sites

- 2010 CEPLA Secondary Sites
- 2010 CEPLA Tertiary Sites
- 2010 CEPLA Quaternary Sites

Projection: GDA94 Zone 56

Figure 28-3

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Flora survey sites, dam and surrounds

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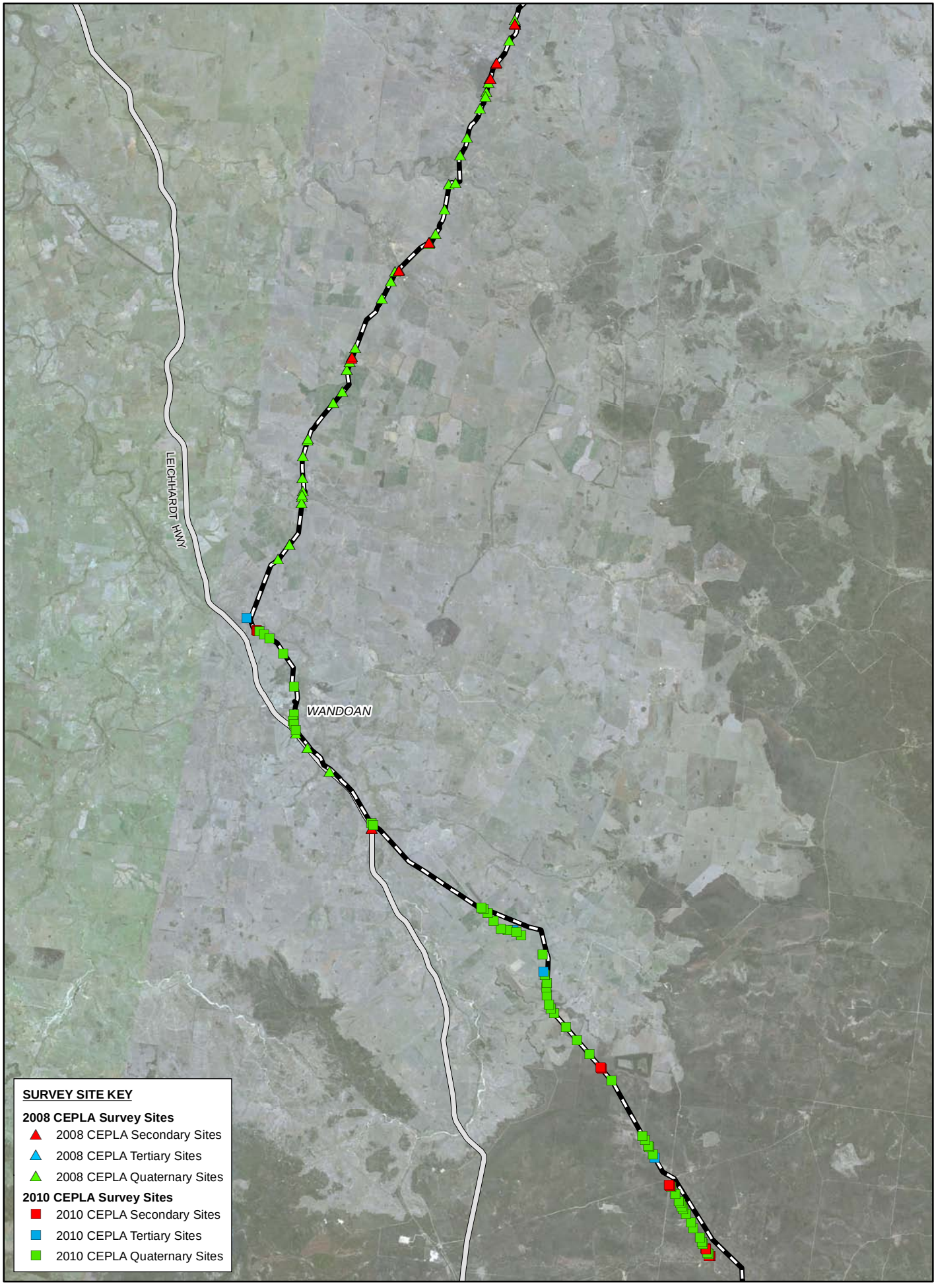

SURVEY SITE KEY

2008 CEPLA Survey Sites
- 2008 CEPLA Secondary Sites
- 2008 CEPLA Tertiary Sites
- 2008 CEPLA Quaternary Sites

2010 CEPLA Survey Sites
- 2010 CEPLA Secondary Sites
- 2010 CEPLA Tertiary Sites
- 2010 CEPLA Quaternary Sites

LEGEND
- Towns
- Pipeline Route
- State Controlled Roads

Projection: GDA94 Zone 56

Figure 28-4A

0 1.5 3 6
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Flora survey sites, pipeline

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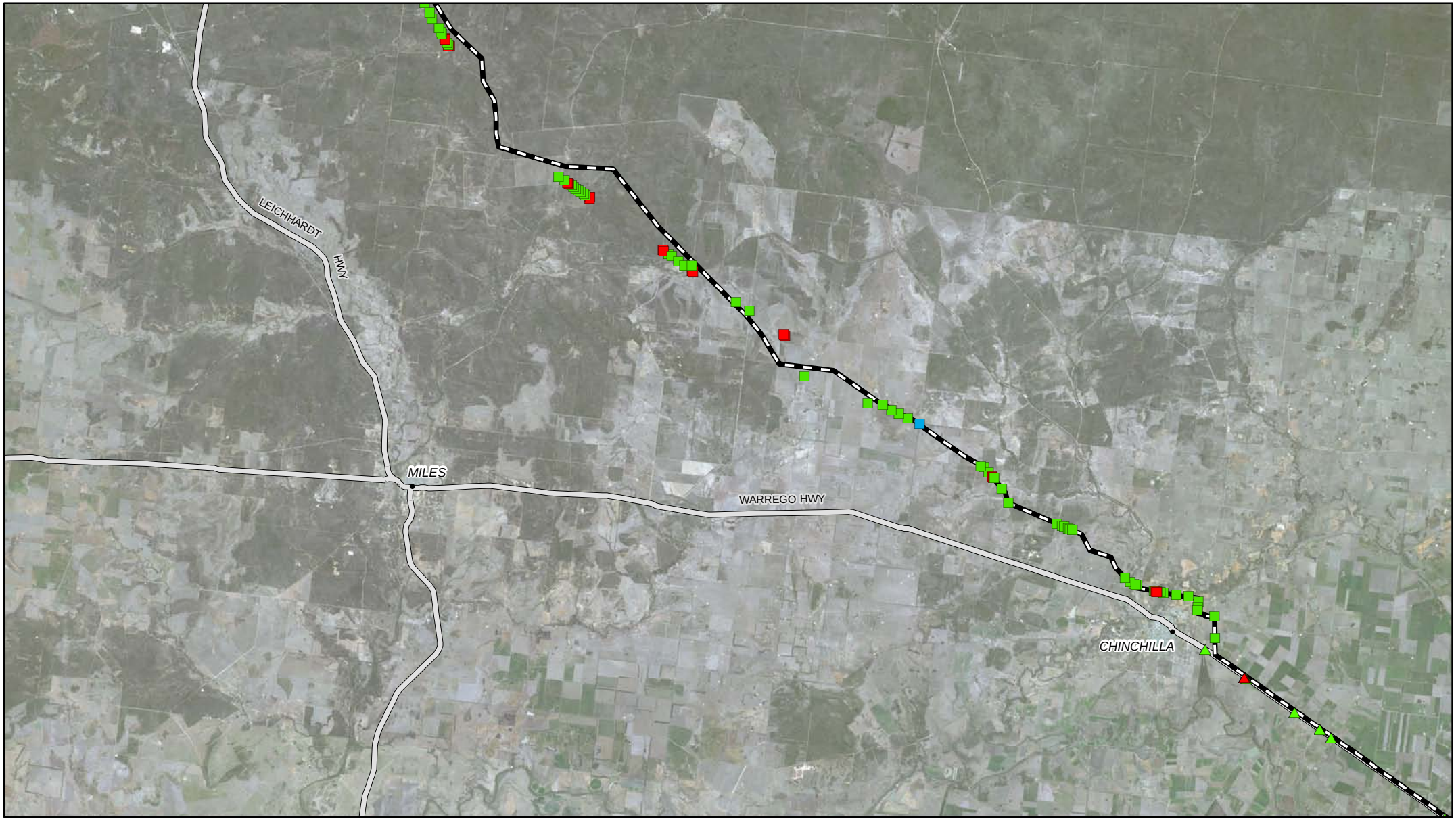

LEGEND

- Towns
- Pipeline Route
- State Controlled Roads

2008 CEPLA Survey Sites

- 2008 CEPLA Secondary Sites
- 2008 CEPLA Tertiary Sites
- 2008 CEPLA Quaternary Sites

2010 CEPLA Survey Sites

- 2010 CEPLA Secondary Sites
- 2010 CEPLA Tertiary Sites
- 2010 CEPLA Quaternary Sites

Projection: GDA94 Zone 56

Figure 28-4B

0 1.5 3 6
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Flora survey sites, pipeline

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LEGEND

- Towns
- Pipeline Route
- State Controlled Roads

2008 CEPLA Survey Sites

- 2008 CEPLA Secondary Sites
- 2008 CEPLA Tertiary Sites
- 2008 CEPLA Quaternary Sites

2010 CEPLA Survey Sites

- 2010 CEPLA Secondary Sites
- 2010 CEPLA Tertiary Sites
- 2010 CEPLA Quaternary Sites

Projection: GDA94 Zone 56

Figure 28-4C

0 1.5 3 6
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Flora survey sites, pipeline

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Terrestrial fauna

Dam and surrounds

A summer/autumn survey of the dam study area was completed by four terrestrial ecologists from SKM between 10 March and 21 March, 2008. Winter surveys were completed between 28 July and 1 August 2008. Total survey effort was approximately 480 hours during summer/autumn and 240 hours during winter, for an overall effort of 720 hours.

A total of 14 comprehensive survey sites were established within the study area during the summer/autumn survey (Figure 28-5). These included four sites where dedicated searches and passive observations were conducted and 10 sites where mammal traps were used. Of these ten sites, pitfall traps were installed at six sites. In addition, four major road transects were surveyed for vertebrate fauna on Cracow Road, Glebe Weir Road, Glebe Road and the Leichhardt Highway. Transects provided incidental data for reptiles, amphibians and mammals.

The winter survey consisted of targeted surveys for herpetofauna, avifauna and mammals, with an emphasis on habitat types which are of seasonal importance to altitudinal migrants and/or provide seasonal foraging resources during winter such as migratory wetland birds (e.g. Australian Painted Snipe *Rostratula australis*).

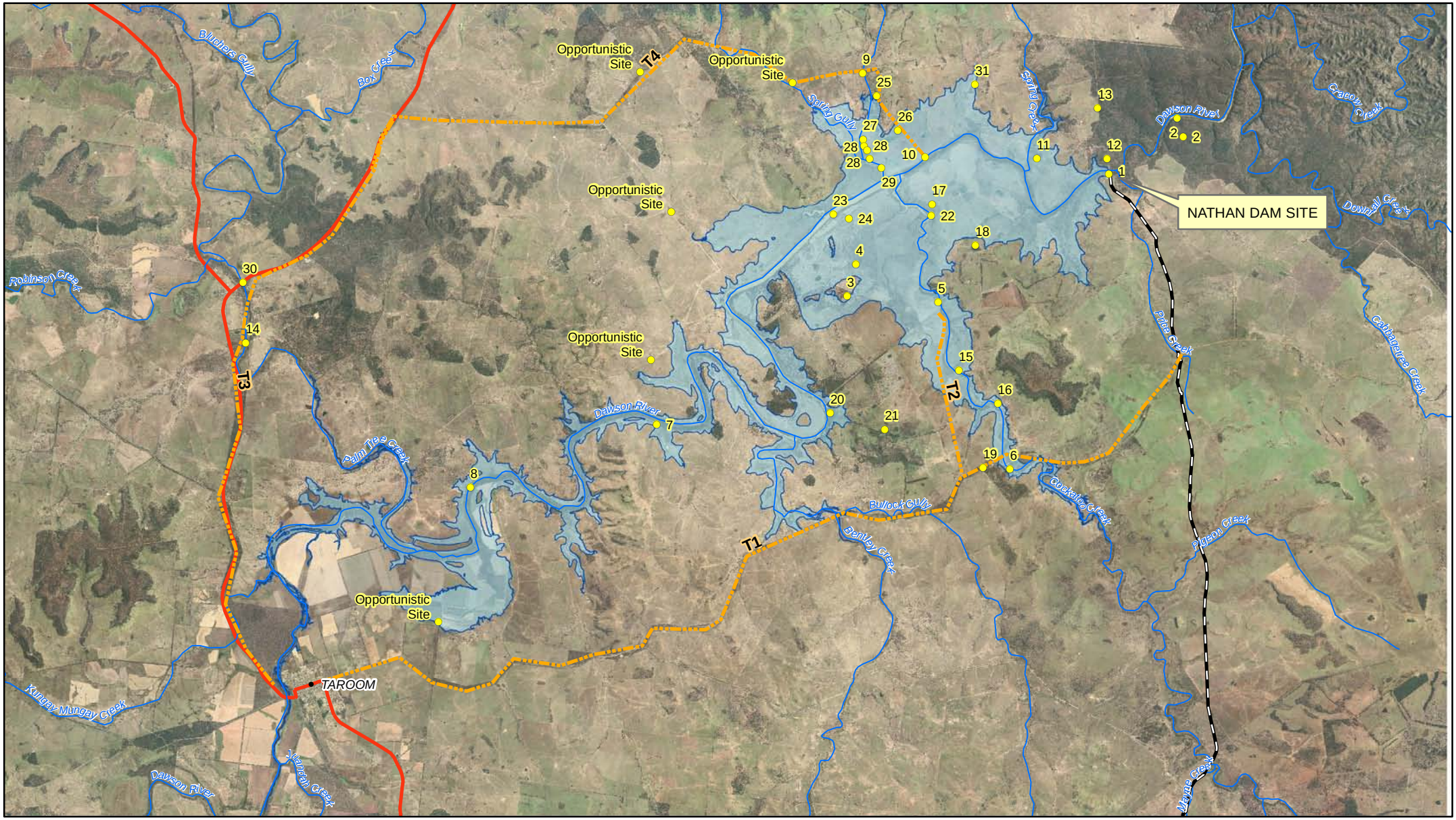
The fauna surveys followed recognised best practice for trapping and survey effort and covered seasonal variations.

Pipeline field surveys

The study area for the proposed pipeline route was defined as a 100 m corridor centred on the relevant sections of the Warrego Highway, Leichhardt Highway and Nathan Road, as well as a refined alignment from Wandoan to Chinchilla. Selection of potential sites in which to conduct rapid habitat assessments was primarily completed through an inspection of the RE mapping and aerial photography for the corridor, which provided an indication of the nature and extent of fauna habitats.

The fauna habitat assessment aimed to assess the quality of the habitat types occurring within the pipeline corridor and particularly the suitability for threatened species. Rapid habitat assessment proformas were completed at each of the sites selected during the desktop selection process. The proformas have been developed to assess general vegetation structure and composition and those habitat features known to influence the use of a site by fauna. Within a one hectare plot the following habitat features were assessed:

- presence / abundance of hollow-bearing trees (live or dead);
- size and number of surface rocks / rock piles;
- approximate coverage and depth of leaf litter;
- structure and diversity of vegetation;
- presence of waterways or wetlands and associated flora;
- presence of riparian vegetation and roost sites in wetlands for waterbirds;
- presence of black cracking clay soils;
- presence of caves or other roost sites for microchiropteran bats; and
- presence of mistletoe.



LEGEND

- Towns of Interest
- Fauna Survey Sites
- Vehicle-based Transects
- Major Roads
- Watercourses
- Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 28-5

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Fauna survey sites, dam and surrounds

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At all rapid habitat assessment sites and some opportunistic sites, dedicated searches for fauna were conducted, with an emphasis on searching for threatened species. Diurnal searches involved the following:

- turning logs and rocks and searching underneath bark and bark piles at the base of trees for reptiles and amphibians;
- fifteen minute point count surveys for birds, whereby the observer stands in the centre of the plot and records all birds seen and heard within the plot. Birds outside the plot and fly-overs were noted as such; and
- searches for scats, tracks and other signs (e.g. scratch marks, feeding scars) of mammal activity within the plot.

In addition to the diurnal searches, nocturnal searches were undertaken using vehicle based transects (excluding the section from Wandoan to Chinchilla due to limited vehicular access). Opportunistic sites were also assessed along the pipeline route and are defined as those sites where brief observational notes on broad habitat conditions or ecological features of interest were noted (e.g. a wetland adjacent to the pipeline corridor).

The field survey of the pipeline corridor was completed from 12 May – 16 May 2008. Twenty-five rapid habitat assessment sites and 25 opportunistic sites were completed during the survey period. A second field survey was undertaken to assess the realignment of the pipeline between Wandoan to Chinchilla. This was completed from 7 June - 10 June 2010.

Boggomoss Snail surveys

During the surveys conducted for the IAS for the Dawson Dam proposal in 1996, the Boggomoss Snail (*Adclarkia dawsonensis*) was discovered within a Great Artesian Basin (GAB) spring on Mt. Rose Station, approximately 1.7 km to the north of Glebe Weir. A specimen of another snail species previously collected from Theodore was later identified as the Boggomoss Snail. In response to this discovery, the Queensland Museum conducted a survey of likely habitat sites within the Taroom-Theodore region. A further population of the snail was identified from the Camping and Stock Reserve at Isla-Delusion Road crossing of the Dawson River ('Isla-Delusion Camping Reserve') located more than 50 km downstream of the proposed dam wall. At the time of the IAS, these two populations constituted the known range of the snail. The snail is now listed as Critically Endangered under the EPBC Act.

Staff from the Queensland Museum completed a survey of the Mt. Rose Station population in 1997 and estimated the population size as less than 100 individuals. The Isla-Delusion Camping Reserve population was estimated at less than 500 individuals. However, these estimates were based on the capture of 18 live snails in a limited number of habitats and consequently a series of targeted surveys have been conducted for the Boggomoss Snail as part of the current EIS to better estimate their population size and distribution. These are described below.

BAAM (2008 and 2009)

Biodiversity Assessment and Management Pty Ltd (BAAM), led by Dr John Stanisic with field assistance by SKM, completed surveys for the Boggomoss Snail in late 2008 within the known sites and within riparian habitat areas along the Dawson River from Taroom to Theodore. Two surveys of nine days were conducted from 7 October to 16 October 2008 and from 24 November to 3 December 2008. The objectives of the study were to:

- determine if the Boggomoss Snail exists at other locations within the Dawson River Valley;
- assess the condition of the Boggomoss Snail populations;

- revise the population size estimate for the Mt Rose boggomoss population;
- obtain additional information about the habitat and microhabitat requirements of the Boggomoss Snail that would assist in the conduct of translocation trials and the recovery of the species; and
- select locations based on the above for the conduct of translocation trials that may also act as sites for potential translocation.

A total of 53 sites were searched within the Dawson River and selected major tributaries, including Cockatoo Creek, Palm Tree Creek and Spring Creek (Figure 28-6). Searching involved turning ground debris and raking through leaf litter. At Mt Rose, searching was very targeted to sandpaper figs and large gum trees. The population estimate was based on multiplying the mean recorded snail density per microhabitat by the number of sandpaper figs / large gums on the site. Further details of the methodology and survey sites are included in Appendix 11-B.

SKM (2009)

SKM completed surveys for the Boggomoss Snail in mid 2009 to quantify the spatial distribution and population size of the snail in the Dawson River catchment. Two targeted surveys of 12 days were conducted from 19 July to 25 July 2009 and from 17 August to 21 August 2009. The objectives of the survey were to locate any additional populations of the Boggomoss Snail outside the range of historic search effort, provide an estimate of the population size within its known distribution and provide preliminary assessment of newly identified habitat areas for translocation purposes. SKM surveyed a total of 109 sites from the upper Dawson Valley (near Injune), downstream to Theodore (Figure 28-6). Searching involved sifting through leaf litter and ground debris. At riparian sites where live snails were found a 100 m transect with sub-plots was established to estimate the population size. The population estimate was based on multiplying the mean recorded snail density per plot (square metre) by the estimated total area of similar habitat on the site. Further details of the methodology and survey sites are included in Appendix 11-C.

JKR Ecological and SKM (2010)

JKR Ecological together with SKM completed targeted surveys for the Boggomoss Snail between 28 June and 2 July 2010 to gather further information on the spatial distribution and population size of the Boggomoss Snail within the Dawson River catchment. The objectives of this survey were to:

- locate any additional populations of the Boggomoss Snail throughout the Dawson River catchment, including outside the range of historic search effort and within areas considered to represent marginal habitat;
- discuss previous population size estimates within its distribution and make comparison between the methodologies employed by BAAM and SKM;
- provide population estimates for newly discovered populations; and
- provide a preliminary assessment of newly identified habitat areas for translocation purposes.

A total of 25 new sites were surveyed (additional to those previously surveyed) for the Boggomoss Snail within the middle Dawson River catchment including the Dawson River itself between Taroom and Baralaba (Figure 28-6). SKM and JKR targeted their surveys to alluvial areas, and then within those areas a greater sampling effort was afforded to moist sites under abundant leaf litter and debris, however there was no focus on particular canopy species. While this approach could be described as making general assumptions regarding microhabitat selection, it is entirely appropriate to the stage of investigation, and the results supported the assumption.

The SKM methodology for population estimate based on available habitat was employed. A conservative approach to estimation was undertaken by:

- not producing estimates from small areas of habitat even if the snail was found there,
- only using live snails,
- not including habitat more than 50 metres from the river, and
- not including areas of potential habitat that had not been physically investigated (because landholder approval had not been gained).

Further detail on the methodology and survey sites is included in Appendix 11-D.

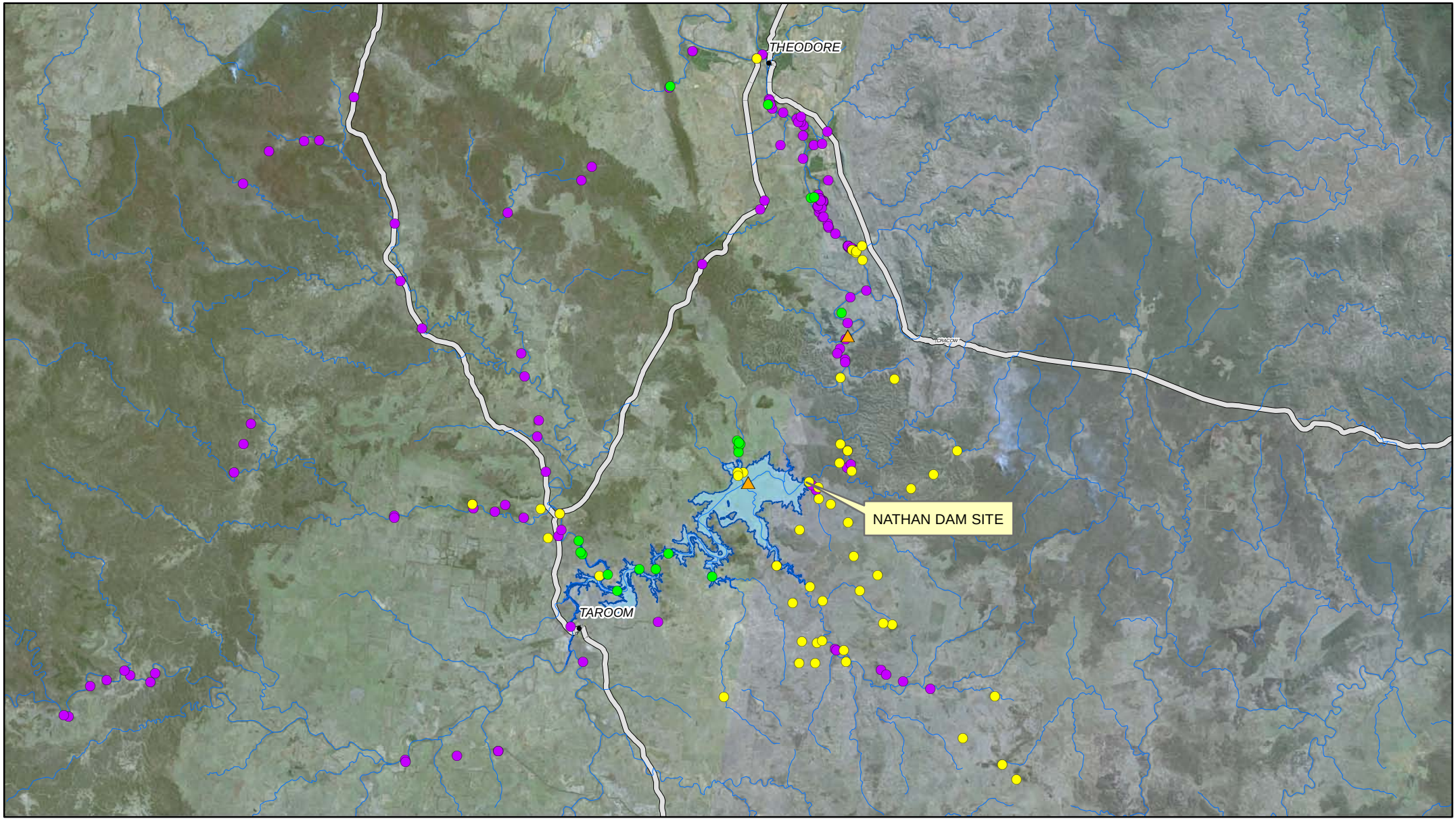
Likelihood assessment

The likelihood of a threatened species occurring within the water storage area or pipeline route was assessed. A hierarchy was used to assess whether a species is known, likely, unlikely or absent from the Project area. These terms are further described as follows:

- Known - Species has been positively recorded in the Project area in this survey or other survey by qualified ecologists during past 30 years;
- Likely – Remnant vegetation or sites likely to support the species because there is habitat containing essential resources of a size capable of supporting a significant number of individuals. Available habitat which is proximal to and buffering a known occurrence of a population;
- Possible - Remnant vegetation may provide suitable habitat which is potentially important however may be known to be suboptimal and there have been no reported records or sightings;
- Unlikely - Vegetation is unlikely to support the species because there have been no reported sightings of individuals and/or the habitat is considered unsuitable based on consideration of literature and field knowledge; and
- Absent Known or suspected– absences consistently recorded based on intensive targeted survey and consideration of habitat and distribution from literature.

An index of confidence is applied to the assessment being:

- High – personal observations or records from other reputable sources (for example, 90% certainty);
- Medium – information from sources of reasonable/mixed reliability (location accuracy / taxa identification) (for example, 70% certainty); and
- Low – information from sources of unknown reliability (for example, 50% certainty).



LEGEND

- Town
- Weir
- Major Roads
- Watercourse
- Full Supply Level (183.5 m AHD)
- JKR (2010) Snail Survey Sites
- SKM (2009) Snail Survey Sites
- BAAM (2008) Snail Survey Sites

Projection: GDA94 Zone 56

Figure 28-6

0 5 10 20
Kilometres

N

Scale 1:700,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Boggomoss Snail survey sites

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28.3.4.2. Results

- Threatened ecological communities

The EPBC search results for the study area (which is larger than the footprint of potential impact) indicates the potential presence of the following threatened ecological communities (ECs):

- Brigalow (*Acacia harpophylla* dominant and co-dominant);
- semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions;
- the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin; and
- Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin

Field surveys identified three threatened ecological communities as occurring within the dam and pipeline study areas. These include:

- Brigalow (*Acacia harpophylla* dominant and co-dominant);
- natural grasslands of the Queensland Central Highlands and the northern Fitzroy Basin; and
- semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions.

The Brigalow EC was recorded within the water storage area and along the pipeline route. The Natural grassland and Semi-evergreen vine thicket (SEVT) ECs were recorded only along the pipeline route. The pipeline has been realigned to avoid the SEVT.

While GAB spring wetlands were identified in the water storage area, dam construction footprint and outside of the impact area, SunWater has reviewed the relevant literature regarding GAB springs and is of the view that the springs within the region of the project are not included within the definition of those that support the threatened ecological community. The basis for this view follows but despite that view, SunWater recognizes ecological values associated with the spring environment and has endeavoured to manage those values responsibly.

The literature describing the spring wetlands of the Great Artesian Basin (GAB) includes many inconsistent and at times ambiguous definitions of 'recharge' and 'discharge' springs. Such conflicting definitions often occur within the one document, meaning that one definition would classify the springs as discharge while another might classify them as recharge (an example is the Recovery Plan). SunWater has taken the view that the debate has often been a hydrogeological one whereas the protected feature of relevance to the listing is "the community of native species", which is an ecological feature. The listing and the Recovery Plan have seen fit to differentiate various types of springs and to exclude those classified as "recharge" from the definition of the community. The discussion below has regard firstly to broad hydrogeological definitions then secondly to ecological issues that differentiate springs in the Project area from those included within the definition of the listed community.

The listing advice states "*The listing .....includes springs within the GAB discharge area (see Figure 4, Great Artesian Basin Consultative Council, 2000)*." That figure is reproduced as Figure 28-8 and while it does not label any discharge areas it does show recharge areas and groundwater flow paths. The Springsure Group, within which the Project is located, is shown as a recharge area and all groundwater flow path arrows go from it, not to it. On this basis, the Springsure group is not within "the GAB discharge area".

The listing advice also states that the Springsure group, amongst others "*include some springs that arise from recharge rejection within the recharge areas of the Basin. These springs are not included in this determination*." The figure referenced above was used as Figure 18 within the earlier Great Artesian Basin Resources Study (GABCC 1998) with the accompanying text "*Springs are quite common in the recharge areas along the eastern margins, but most of these springs are the result of 'overflow' or the 'rejection' of recharge into the aquifers, or result from the interaction between the local topography and aquifers (i.e. spring groups A, B and L on Figure 18)*". The Springsure group is labelled as group B hence the springs in this region are considered recharge springs.

The Recovery Plan and the SPRAT profile also clearly state that recharge springs are not part of the listed ecological community. The profile also excludes springs arising for the Hutton or Precipice sandstone and the project only impacts springs that arise from these geological features.

With respect to ecological characteristics the listing advice states; "*the community is characterised by combinations of native species that may occur more widely that the GAB, as well as endemic species (restricted to one or more GAB spring)*" (Threatened Species Scientific Committee, 2001q). Hence, to be included within the listed community, a spring community must have endemic species present. There are some inconsistencies between the listed classification and the categories of GAB springs provided in the recovery plan. To determine a GAB spring based on the presence of a combinations of native species as well as endemic species relates only to category 1a GAB springs in the recovery plan. This assessment is based on the listing advice not the categories of GAB springs provided for in the recovery plan. As the community is those species that "depend" on the spring, reliance on endemism as a characterising feature is reasonable. With respect to the certainty with which springs have been determined as containing endemic or important species, the Recovery Plan commonly places a high level of certainty on the conclusions. This is not surprising with respect to springs in the Project impact area because they have been thoroughly investigated as a part of previous impact assessments, including by the author of the Recovery Plan. Appendix 2 of the Recovery Plan lists species endemic to discharge spring wetlands and the springs database (a background document to the Recovery Plan; Fensham and Fairfax 2008) confirms the endemic *Eriocaulon carsonii* and *Myriophyllum artesium* as being present in the Cockatoo Creek complex within the Springsure group. Cockatoo Creek will not be impacted by the Project. The Recovery Plan also identifies habitat critical to the survival of *Eriocaulon carsonii* and this is not within the area of the Project. The undescribed plant *Plantago* sp. (RJ Fensham 3677) is also listed as from the Springsure supergroup however the exact location of the records is not currently known.

The recommendation of the listing advice was that the community was eligible for listing under Criterion 2. The justification against that criterion centred on a "*reduction in active springs*" brought about by "*draw down*". Draw down, or a reduction in water flow, was also used as the only basis for listing under Criterion 1. Table 3 of the Recovery Plan shows that no spring complexes in the Springsure group have become inactive and Table 5 of Fensham and Fairfax (2003) shows the flow rate from discharge springs to be as low as 5% of their original level while that of recharge springs were at least 92.7% and Springsure was 99.5%. Clearly the core threat that resulted in the community being listed as threatened, does not apply to the Springsure group.

Appendix 3 of the Recovery Plan provides additional information on EPBC listed species associated with the GAB discharge springs ecological community. None of the species listed are known from the impact area nor are any complexes within the Springsure group listed in Table 5 of the Appendix. This is because the list is based on the

recharge/discharge distinction used by Fensham and Fairfax (2003) and that report classified all Springsure group springs as recharge so they would not be included within the definition of the endangered ecological community.

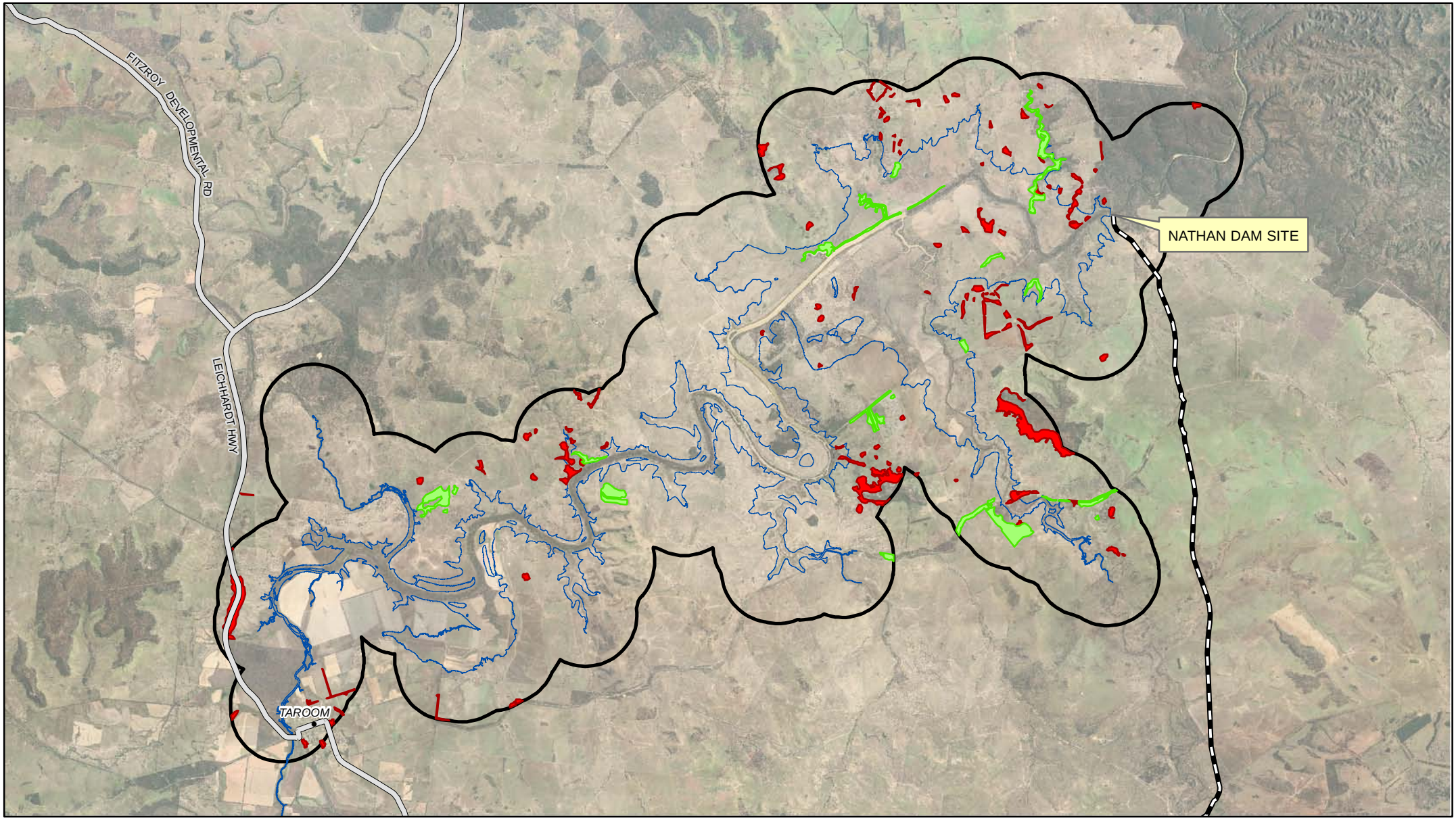
Table 2 of the Recovery Plan summarises the "*exceptional values*" of category 1a spring complexes and includes Boggomoss (a complex of springs within the Springsure group) on the basis of the presence of the Boggomoss Snail (*Adclarkia dawsonensis*) at (then) one spring. This classification is incorrect because the Boggomoss Snail was (then) also known from Isla Delusion crossing where it was not associated with a spring. The Boggomoss Snail is clearly not endemic to springs and further information in this EIS has shown that conclusively. There are no other Springsure group springs with "exceptional values" listed in Table 2.

SunWaters approach to the threatened species which are or may be found on springs impacted by the Project is to address them as listed threatened species in their own right. Readers are referred to assessments of Boggomoss Snail and Hairy Joint Grass (*Arthraxon hispidus*). No other threatened species are known to be associated with springs within the impact area of the Project.

The wetlands associated with the springs are protected under the State Vegetation management Act and are treated as an Of Concern Remnant Ecosystem for impact assessment and offsetting purposes.

Although the ToR made specific reference to the Critically Endangered EC White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland it was not found in either the dam or pipeline study areas. The Weeping Myall Woodlands EC was also not found within either the dam or pipeline study areas.

The threatened ECs, corresponding REs and maximum areas impacted for each EC are shown in Section 10. The distribution of the Brigalow EC across the dam study area is shown in Figure 28-7. The distribution of GAB spring wetlands across the dam study area is shown in Figure 28-8.



LEGEND

- Town
- Pipeline Route
- State Controlled Roads
- Dam Study Area
- Full Supply Level (183.5m AHD)

Brigalow Ecological Communities

- Dominant Endangered - Brigalow
- Sub-dominant Endangered - Brigalow

Projection: GDA94 Zone 56

Figure 28-7

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Distribution of the Brigalow ecological communities across the dam study area

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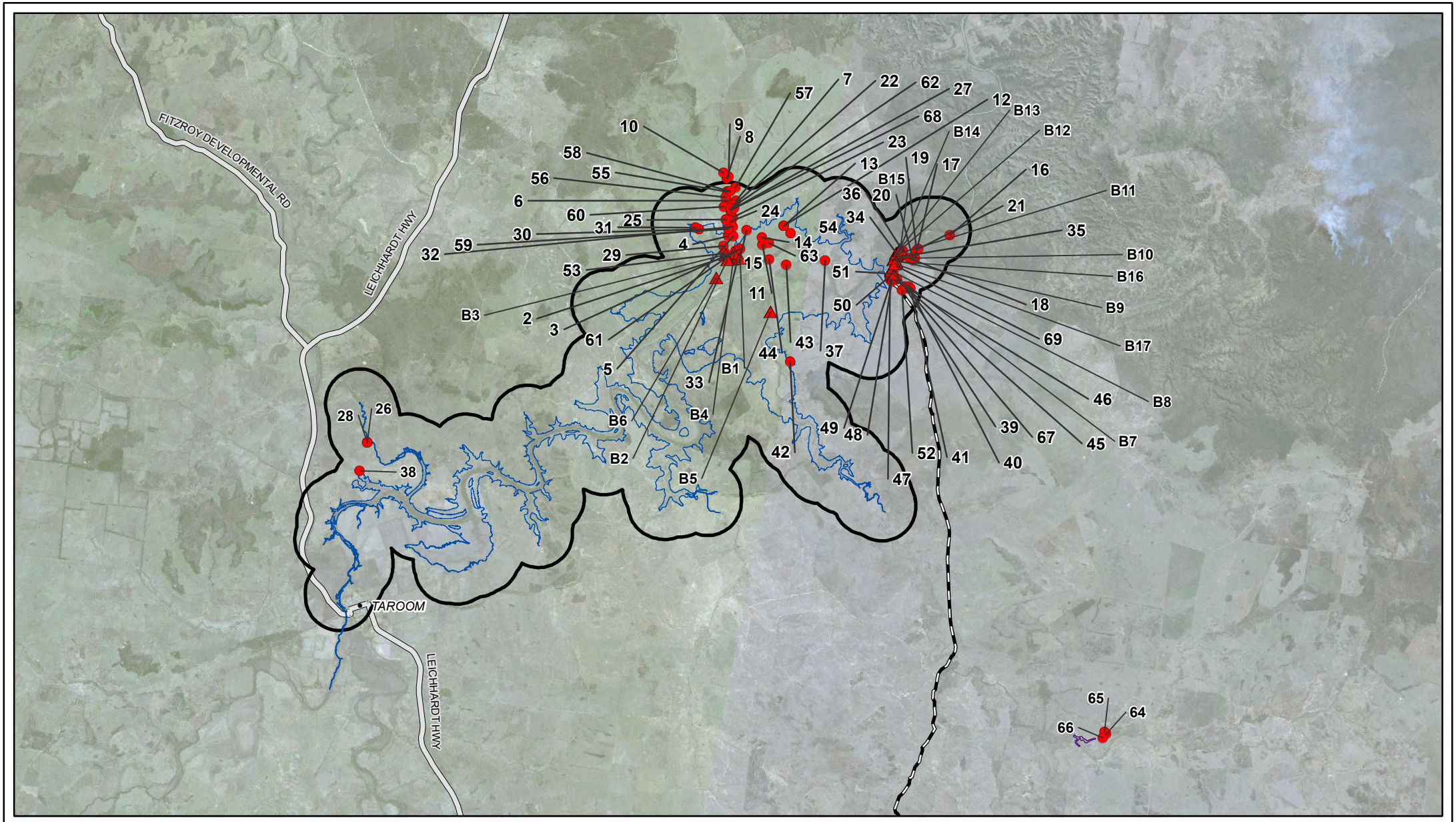

LEGEND

- Towns
- Pipeline Route
- State Controlled Roads
- Other Infrastructure
- Full Supply Level (183.5m AHD)
- Springs mapped by Fensham and Fairfax (2005)
- Springs mapped by CEPLA (2008)

Projection: GDA94 Zone 56

Figure 28-8

0 1.5 3 6
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Distribution of GAB spring communities across the dam study area

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Brigalow (*Acacia harpophylla* dominant and co-dominant)

Current distribution

The Brigalow (*Acacia harpophylla* dominant and co-dominant) EC occurs as scattered remnants predominantly within the Brigalow Belt North, Brigalow Belt South, Darling Riverine Plains and Southeast Queensland bioregions, with smaller amounts in the Mitchell Grass Downs, Mulga Lands and Einasleigh Uplands bioregions. The community extends from south of Charters Towers in Queensland, in a broad swathe east of Blackall, Charleville and Cunnamulla, south to northern New South Wales near Narrabri and Bourke (Bulter, 2007).

In Queensland, the Brigalow EC that has been listed under the EPBC Act is defined by reference to 16 REs, all of which are listed as Endangered under the Queensland *Vegetation Management Act 1999* (VM Act).

Ecology

The floristic composition of the Brigalow EC is well documented. In the southern Brigalow Belt, Brigalow is commonly found with Belah (*Casuarina cristata*); however, sometimes monotypic stands are present. Common understorey species include Wilga (*Geijera parviflora*), Sandalwood (*Eremophila mitchellii*), Boonaree (*Heterodendrum diversifolium*), Lime Bush (*Eremocitrus glauca*), Ellangowan Poison Bush (*Myoporum deserti*) and Black Tea Tree (*Melaleuca bracteata*).

In mature stands, the grass/herbaceous layer is sparse and ephemeral. Where present, the ground layer is characterised by genera such as *Atriplex*, *Bassia*, *Chloris*, *Leptochloa*, *Paspalidium* and *Sporobolus*, which tend to be more prominent in years of higher rainfall.

West *et al* (1999) surveyed regrowth and remnant Brigalow stands, identifying differences in floristics, structure and ecological health of the stands. They found that narrow stands tended to have short, dense tree and shrub layers, with understorey dominated by edge species. In contrast, wider stands displayed more open tree and shrub layers, as well as spatial variation in species and structure.

Isbell (1962) identified five broad soil groups supporting Brigalow dominated vegetation:

- deep gilgaied clay soils;
- sedentary clay soils;
- alluvial clay soils;
- miscellaneous deep clay soils; and
- light-textured red soils.

The two main clay groups (deep gilgaied clays and sedentary clays) cover approximately 86% of the Brigalow Belt (DEWHA 2009c). The phrase ‘gilgaied soil’ is used to refer to soils with alternating mounds and depressions, which result in an irregular, undulating land surface (DEWHA 2009c).

A distinctive feature of Brigalow vegetation is its capacity to sucker freely from an extensive system of shallow, lateral roots. Suckering is initiated when there is any damage to aerial parts of the vegetation or to lateral roots.

Brigalow ECs are particularly susceptible to fire, with hot fires being able to burn mature vegetation. Under most circumstances the practice of burning tends to induce suckering from lateral Brigalow roots. If no further management is applied to a burnt Brigalow EC, it is likely to revert to its original condition. If an area has been cultivated for a number of consecutive years Brigalow suckering is likely to be negligible.

In terms of regrowth development, the average growth rate of Brigalow suckers has been measured at approximately 30 centimetres (cm) in height each year over the first 5-10 years, with growth being particularly rapid in the early stages. The growth rate of Brigalow tends to slow down after 10-15 years, being extremely slow from 20 years onwards.

Brigalow vegetation has a recognised tendency to develop extensive horizontal root systems, typical of trees in environments where there is no access to the groundwater table. Most of the soil water fluctuations underneath Brigalow trees occur in the top one metre section of the soil.

Populations within the area affected by the proposed action

The distribution of the Brigalow EC across the dam study area is shown on Figure 28-7. Four REs comprising Brigalow are present within the dam study area (REs 11.3.1, 11.9.1, 11.9.5 and 11.9.5a) and four within the pipeline easement (REs 11.3.1, 11.4.3, 11.9.5 and 11.9.6). The Queensland Herbarium's Regional Ecosystem Description Database (REDD) (Queensland Herbarium 2009) describes these RE's as follows:

- 11.3.1 – *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains;
- 11.4.3 – Open-forest dominated by *Acacia harpophylla* and/or *Casuarina cristata*;
- 11.9.1 – *Acacia harpophylla-Eucalyptus cambageana* open forest to woodland on fine-grained sedimentary rocks;
- 11.9.5 – *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks;
- 11.9.5a - *Acacia harpophylla* predominates and forms a fairly continuous canopy (10-18 m high). Other tree species such as *Eucalyptus populnea, Casuarina cristata, Cadellia pentastylis* and *Brachychiton spp*. may also be present in some areas and form part of the canopy or emerge above it. Scattered *Eucalyptus orgadophila* may occur, especially on upper slopes and crests. A dense tall shrub layer dominated by a range of species is usually present, while a more open low shrub layer often occurs. Common species in these layers include *Croton insularis, Denhamia oleaster, Apophyllum anomalum, Croton phebalioides, Alectryon diversifolius* and *Carissa ovata*. The ground layer is sparse, most frequently composed of *Ancistrachne uncinulata* and *Eragrostis megalosperma* and varies with the density of the shrub layers. Occurs on undulating plains and rises formed mainly on shale's. The soils are predominantly cracking clay soils, which are strongly alkaline at or near the surface and acidic beneath, or dark brown and grey-brown gradational soils, with a coarse-textured surface grading into an alkaline, clayey subsoil; and
- 11.9.6 – '*Acacia melvillei* ± *A. harpophylla* open forest on fine-grained sedimentary rocks.'

A total of 212.9 ha of the Brigalow EC is located within the Project area (i.e. the footprint of impact). This includes 200.6 ha in the dam and surrounds, 1.7 ha along the pipeline and 10.6 ha in the associated infrastructure.

Current pressures on the community

In Queensland, the original extent of the Brigalow EC was estimated to be more than 7.3 million hectares (Butler, 2007). In 2003, about eight per cent remained (Butler 2007). Core areas with remnants are located in the Northern Bowen Basin, Belyando Downs, Isaac-Comet Downs and Claude River Downs subregions of the Brigalow Belt North bioregion

(total area of Brigalow about 256,000 ha), and in the Southern Downs and Moonie River-Commoron Creek Floodout subregions of the Brigalow Belt South Bioregion (total area of Brigalow about 110,000 ha) (Butler, 2007).

Existing controls and planning regimes

Clearing of the Brigalow EC is strongly regulated, with all 16 of the RE's which characterise the community in Queensland being listed as Endangered under the VM Act. Remnant and regrowth Brigalow more than 15 years old is also protected under the EPBC Act.

A national recovery plan for the Brigalow EC has been prepared (Butler, 2007) and will become the primary framework for the community's recovery. The main objective proposed is to conserve and enhance the environmental values of the Brigalow EC over the long term, by working to increase the extent of both remnant and regrowth Brigalow and improving its condition and management.

Specific objectives proposed for the recovery plan are to:

- increase the area of the Brigalow EC and its representation in conservation reserves;
- improve knowledge of the Brigalow EC and its condition as habitat for native species; and
- mitigate key threats to the Brigalow EC by controlling fire, weeds and animal pests.

Natural grasslands of the Queensland Central Highlands and the northern Fitzroy Basin

Current distribution

The Natural grasslands EC is endemic to Queensland and occurs in the Brigalow Belth North and Brigalow Belt South bioregions. The grassland extends from Collinsville in the north to Carnarvon National Park in the south and is bounded to the south by the Expedition, Carnarvon, Great Dividing, Drummond and Narrien ranges; and to the north by the Clark, Denham, Connors and Broadsound ranges (TSSC, 2008adr).

Ecology

The Natural grasslands are native grasslands typically composed of perennial native grasses and are found on soils that are fine textured (often cracking clays) derived from either basalt or fine-grained sedimentary rocks, on flat or gently undulating landform. These grasslands occur in areas with relatively high summer rainfall and a tree canopy usually absent, or where present, the projective crown cover is no more than 10% (TSSC, 2008adq).

The grasslands are typically composed of a mixture of forbs and native grasses and are mostly dominated by *Dichanthium* spp. (bluegrasses), with tropical *Aristida* spp. (three-awned grasses) and *Panicum* spp. (panic grasses). Drier sites may include a higher proportion of *Astrebla* spp. (Mitchell grasses) (TSSC, 2008adq).

The key diagnostic features of these Natural grasslands are (TSSC, 2008adq):

- they occur within the Brigalow Belt North and South subregions, which are largely within the Central Highlands and northern Fitzroy River Basin regions of Queensland;
- tree canopy is absent or sparse (less than 10% projective crown cover). If the grassland was derived from cleared woodland then it is not part of the ecological community; and

- the ground layer is typically dominated by perennial native grasses and contains at least three of the indicator native grass species.

Populations within the area affected by the proposed action

One RE 11.3.21 (*Dichanthium sericeum* and/or *Astrebla* spp. grassland on alluvial plains cracking clay soils) which comprises the Natural grassland EC is present within the pipeline study area. A narrow linear patch is present within the roadside of the Warrego Highway at Macalister. The pipeline has been aligned to avoid this patch. However, 0.07 ha of Natural grasslands is still located in the corner of the 30 m wide pipeline easement. There is no Natural grassland EC located within the dam and associated infrastructure study areas.

Current pressures on the community

Native tussock grasslands, such as the Natural grasslands of the Queensland Central Highlands and the northern Fitzroy Basin, once occurred over a large area of Australia (TSSC, 2008adq). The main current threats to the EC are grazing, cropping and pasture improvement, weeds and pest animals, mining activities and construction of roads and other infrastructure. The main potential threats are lack of knowledge about grasslands, climate change (TSSC, 2008adr) and future development.

Existing controls and planning regimes

In Queensland, the Natural grasslands EC that is listed as Endangered under the EPBC Act is defined by seven REs, two of which are listed as Endangered under the VM Act (RE 11.3.21 and 11.9.12).

Existing management plans relevant to the Natural grasslands ecological community include the draft recovery plan for the previously listed Bluegrass (*Dichanthium* spp.) dominant grasslands of the Brigalow Belt Bioregions (north and south) (Butler, 2007).

Semi-evergreen vine thickets of the Brigalow Belt (north and south) and Nandewar Bioregions

Current distribution

Remnant SEVT patches are mostly scattered from coastal dunes and river deltas in the vicinity of Townsville and Ayr through the northern and central parts of the Brigalow Belt Bioregion to its south-eastern parts between Jandowae and Killarney on the Queensland/New South Wales border (McDonald, 2010).

Ecology

SEVT is considered an extreme form of dry seasonal subtropical rainforest (McDonald 1996). It occurs in areas with a subtropical, seasonally dry climate on soils of high to medium fertility and is generally characterised by the prominence of trees with microphyll sized leaves (2.5–7.5 cm long) and the frequent presence of swollen-stemmed bottle trees (*Brachychiton australis, B. rupestris*) as emergents from the vegetation (e.g. Webb 1959, 1968; Webb & Tracey 1981, 1994) (cited McDonald, 2010).

There is considerable variation in the height, density of the canopy and the number of strata in SEVT vegetation (McDonald 1996). Within a given region, species richness declines as rainfall decreases and/or becomes more seasonal (Fensham 1995; McDonald 1996) (cited McDonald, 2010).

SEVT in the Brigalow Belt South are floristically diverse and heterogeneous, especially in the canopy layer (Speck *et al*. 1968; Story *et al*. 1967; Gunn & Nix 1977) and often also in the shrub layer (Gunn & Nix 1977; McDonald 1996). They are most common on undulating plains on fine-grained sedimentary rocks (frequently shale) and on basalt hills and plains (based on Qld EPA 2005b) (cited McDonald, 2010).

Populations within the area affected by the proposed action

One RE 11.9.4a, which comprises the SEVT EC is present within the pipeline study area. The REDD (Queensland Herbarium, 2009) describes this RE as follows:

RE 11.9.4a - Semi-evergreen vine thicket, generally dominated by a low tree layer (5-10m high) which is floristically diverse and variable. Common co dominant species include *Croton insularis, Denhamia oleaster*. There is also a tall and low shrub layer (2-6 m high) dominated by species such as *Ehretia membranifolia, Apophyllum anomalum, Geijera parviflora, Capparis* spp*., Croton phebalioides, Erythroxylum australe, Alectryon diversifolius* and *Carissa ovata*. Emergents (16-25 m high) are usually present including species such as *Cadellia pentastylis* and *Brachychiton spp*. usually on better sites, and *Eucalyptus orgadophila* and *Casuarina cristata* on drier, poorer sites. Vines are frequent. The ground layer is very sparse, and is most frequently composed of *Ancistrachne uncinulata* and *Eragrostis megalosperma*.

The SEVT EC is located as a fragmented patch adjacent to the roadside of Nathan Road south of the dam wall site. No SEVT is located within the 30 m wide pipeline easement. The SEVT EC is not located within the dam or associated infrastructure study areas.

Current pressures on the community

Over most of its range in Queensland, the SEVT EC has been extensively cleared for cropping and grazing and/or pasture (Benson 1987; McDonald 1996; Qld EPA 2005b). The SEVT EC covered approximately 1,152,000 ha of land within the Brigalow Belt Bioregion prior to European clearing activities. By 2003, approximately just 146,000 ha of the SEVT in the Brigalow Belt Bioregion remained (17% of its pre-clearing extent) (cited McDonald, 2010).

The main on-going threats to SEVT remnants include clearing, inappropriate fire regimes, invasion by introduced plant species and increased grazing by domestic stock and native animals (Curran 2006; McDonald 1996; Qld EPA 2005b) (cited McDonald, 2010).

Existing controls and planning regimes

In Queensland, the SEVT EC that is listed as Endangered under the EPBC Act is defined by ten REs, four of which are listed as Endangered under the VM Act (REs 11.3.11, 11.4.1, 11.8.13 and 11.11.18).

A national recovery plan for the SEVT EC has been prepared (McDonald, 2010) and will become the primary framework for the community's recovery. The overall objective of this plan is to maintain and conserve the environmental values of the SEVT ecological community over the long term, by minimising the loss of both remnant and regrowth SEVT and improving their condition and management. The recovery plan recommends specific actions to achieve this objective.

- GAB spring wetlands

As noted in Section 28.3.4.2, SunWater considers that the wetlands in the impact area do not fit the definition of the threatened community. Nonetheless, the community is described below for sake of completeness and does not affect SunWater's position with regard to the previous statement.

Current distribution

GAB discharge spring wetlands are located on the northern, western and southern margins of the Great Artesian Basin (GAB) in Queensland, New South Wales and South Australia (Figure 28-9). Their distribution has been accurately described (Pickard 1992; Fatchen 2000; Fensham & Fairfax 2003 & Ponder 2004). Locations include springs that are known to have become inactive during the last 150 years. It is possible that GAB discharge spring wetlands will appear in new locations and the list of known localities may require revision in the future (Fensham *et al*., 2010). In total there are 12 supergroups in Australia, each with 1-85 active complexes totalling 156 active complexes. In the region of the Project, the Boggomoss and Dawson River complexes form part of the Springsure Supergroup. There are currently 266 active springs in the Springsure Supergroup (Fensham, Ponder & Fairfax 2007).

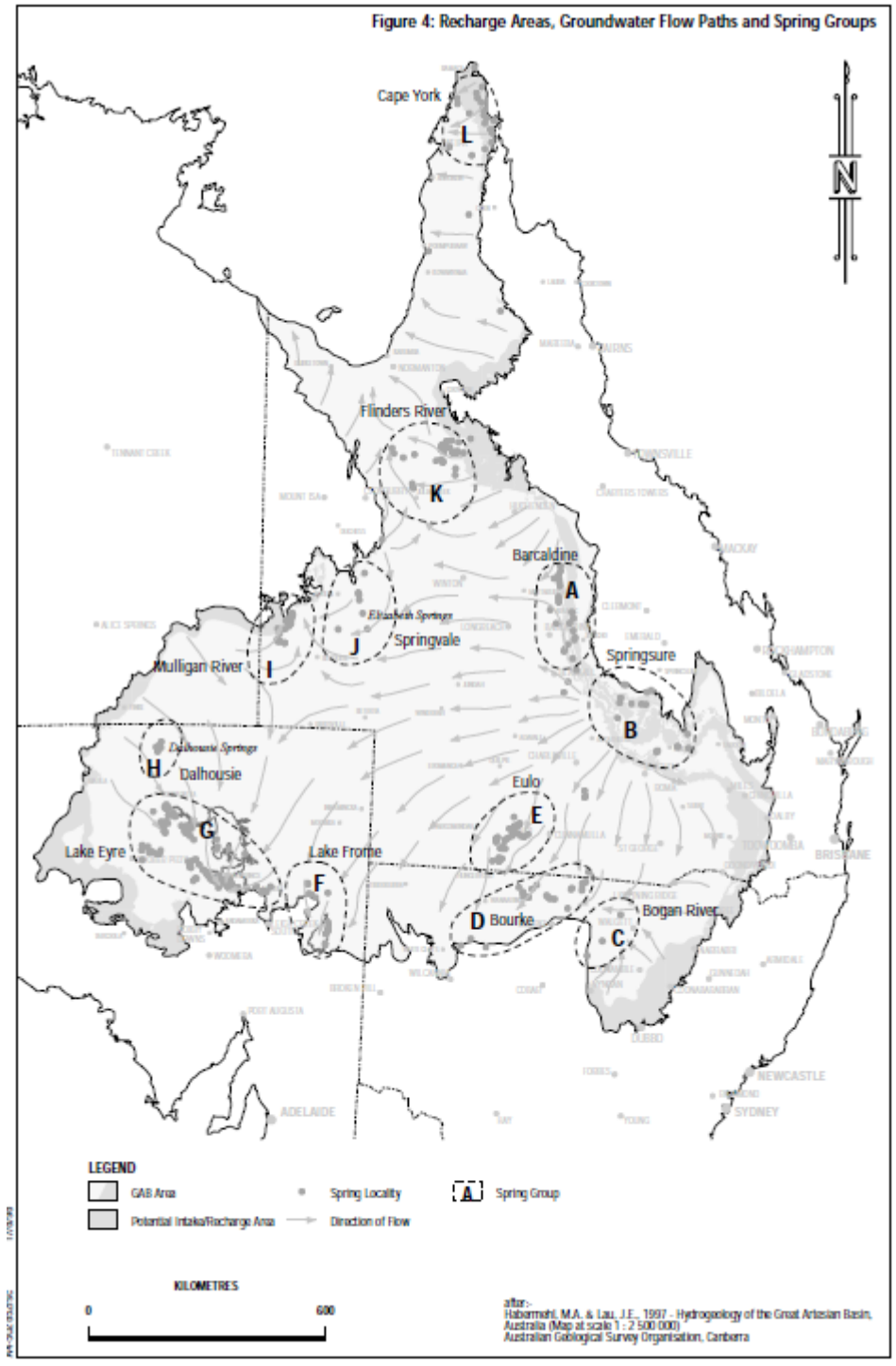


Figure 28-9 Map of the Great Artesian Basin
Reproduced from *Great Artesian Basin Strategic Plan (Great Artesian Basin Consultative Council, 2000)*

This community includes spring wetlands fed by discharge of GAB groundwater except where springs occur within outcrop areas of the following sandstone formations on the eastern margins of the GAB: Adori, Boxvale, Clematis,

Expedition, Gilbert River, Griman Creek, Gubberamunda, Hampstead, Hooray, Hutton and Precipice sandstones, the Bulimba, Glenidal, Moolayember, Piliga, Rewan, Wallumbilla and Westbourne formations, and the Helby and Ronlow Beds. Springs in the Project area are sourced from the Precipice or Hutton sandstones. The springs typically occur through fault structures where there is abutment with bedrock or where the confining beds are sufficiently thin to allow discharge of groundwater close to the surface.

Springs which are not included in this community are recharge springs which are generally associated with outcropping sandstone, which can form rugged landscapes with springs often situated in gullies and providing the source for streams. Sodic and salty non-wetland areas, although intimately associated with spring wetlands, are not included in the listing. There are also springs within the GAB envelope with water emanating from Tertiary aquifers positioned above the GAB sequence (Habermehl 1982; Fensham *et al*. 2004a) and these are not included in the listing.

Ecology

GAB discharge springs occur from the southern end of Cape York Peninsula to Lake Eyre in South Australia, spanning tropical semi-arid and temperate arid climates. The discussion below includes reference to the whole community and may not reflect only the springs in the study area. The springs occur under a range of circumstances (Habermehl 1982, 2001) including where:

- water-bearing sediments approach the ground surface near the margins of the GAB;
- water flows through faults or unconformities in the overlying sediments; and
- a conduit is provided at the contact between the confining sediments and the outcropping of bedrock (e.g. granites).

The discharge spring wetlands vary in size from miniscule (<1 m^2) to over 100 ha. In some locations, the spring wetlands include pools but usually they form vegetated swamps. In all cases the spring wetlands can be distinguished from most other wetlands of the region because they are not subject to seasonal drying out and are sustained by a relatively constant water supply. This latter characteristic of spring wetlands supports a suite of organisms including perennial wetland plants that are distinct from those in seasonal wetlands.

Most water discharging from the springs is less than 30°C. The water chemistry of the discharge springs is variable, with pH values between 6 and 10 and conductivity between 500 and 12,000 µS/cm (Williams 1979; Mitchell 1985, Smith 1989; Queensland Herbarium unpub., Niejalke unpub., Pickard 1992).

The vegetation patterns within individual springs is at least partly due to succession processes, with the development of new wetland areas caused by changes in spring flows. Patterns are also probably related to variations in water chemistry and substrate which have profound effects on both plant and animal distributions within individual springs (Fensham *et al.* 2004b).

Many of the spring endemic invertebrates are dependent on well oxygenated flowing water, which is often extremely shallow (one to a few millimetres). Shelter, for example from fallen trees, rocks and sedges, is also important within these flows. Such habitats are extremely vulnerable to trampling or changes in water flow (Graham 1998). Some elevation of the spring-head is essential to allow water flow critical for the survival of many of the endemic aquatic animals. Springs feeding directly into small standing pools rarely contain endemic fauna. The patterns of plant and animal distributions within individual spring wetlands and the detailed effects of disturbance and changes in water flow are poorly understood.

The plant composition and structure is highly variable. Spring wetlands are not usually dominated by woody vegetation. In some situations the springs can support dense stands of reeds *Phragmites australis* up to 5 m tall. Tussock forming sedges (e.g. *Fimbristylis* sp.) or grasses (e.g. *Sporobolus pamelae*), or mat forming sedges (e.g. *Cyperus laevigatus*) and herbs (e.g. *Eriocaulon carsonii*) dominate other spring wetlands. Where the springs have been heavily disturbed, for example by excavation, a host of widely occurring native (e.g. *Cyperus difformis, C. polystachyos, Typha orientalis*) and non-native (e.g. *Cynodon dactylon, Echinochloa colona, Paspalum distichum*) wetland species become abundant.

Thirteen vascular plant species from GAB discharge spring wetlands are endemic to spring wetlands. Endemic plant species in the Springsure supergroup which is relevant to the study area include *Eriocaulon carsonii, Fimbristylis blakei, Myriophyllum artesium* and *Plantago* sp. The permanently wet habitats of GAB discharge spring wetlands also support populations that are extremely isolated from other populations of the same species, i.e. *Pennisetum alopecuroides* in western and southern Queensland.

Several endemic fauna species have also been recorded from spring wetlands including 8 fish species and 38 snail species. In addition to the endemic fauna, spring wetlands provide suitable habitat for a wide variety of aquatic animals, mainly insects and their larvae and oligochaete worms. Frogs have been recorded from some spring pools and many bird species and grazing mammals use the spring wetlands. The damp edges harbour a variety of arthropods, notably spiders and mole crickets, and occasionally reptiles. With a few exceptions, the non-endemic animals appear to be widespread, being found in, or associated with, other waterbodies.

Populations within the area affected by the proposed action

This discussion addresses springs in general because SunWater is of the view that springs in the region are not included within the definition of the threatened ecological community.

Field investigations by CEPLA identified an additional six GAB spring communities not mapped by Fensham & Fairafx (2005) and the location of GAB spring communities was refined. Nathan Gorge and lower portions of Price Creek were found to support numerous springs within the bed and banks, several of which were no more than a few metres in diameter. It is possible these smaller springs were regarded by Fensham & Wilson (1997) as 'outbreaks' of the much larger GAB spring communities (up to 300 m x 50 m as measured in GIS) and were therefore not recorded separately by Fensham & Fairfax (2005). Therefore they may not be additional springs, but rather outbreaks of the larger GAB spring communities.

The location of GAB spring wetlands mapped by Fenhsam & Fairfax (2005) and CEPLA (2009) are shown on Figure 28-17. These springs form part of the Springsure Supergroup community. Photos of GAB spring wetlands located within the water storage area are shown in Figure 28-10.

GAB spring communities are classified under the regional ecosystem framework as either RE 11.3.22 Springs associated with recent alluvia, but also including those on fine-grained sedimentary rocks, basalt, ancient alluvia and metamorphic rocks, or RE 11.10.14 Springs associated with sandstone. GAB spring communities within the water storage area generally associated with RE 11.3.22, and those within Nathan Gorge with RE 11.10.14. Both of these REs are listed as Of Concern. The number of GAB springs within and outside of the FSL are listed in Table 28-7.

Table 28-7 GAB spring wetlands recorded within the dam study area

	Water Storage Area	Outside FSL	Totals
GAB spring wetlands mapped by Fensham & Fairfax (2005)	22	44	66
Additional GAB springs mapped by CEPLA (2009)	6	11	17
Total	**28**	**55**	**83**

Figure 28-10 Photos of GAB spring wetlands located in the water storage area (Chenoweth, 2009)

Current pressures on the community

The main threats to the listed community are:

- aquifer draw-down from extraction bores, in particular associated with mining, coal seam gas extraction and geothermal mining;
- excavation of springs, due to the perception that this will enhance flows and improve the access of stock to water;
- establishment and proliferation of exotic plants;
- stock and feral animal disturbance, including grazing and trampling, pig rooting;
- exotic aquatic animals posing a threat to native fauna through predation and competition;
- tourist access, including trampling of wetland vegetation and practices associated with bathing (i.e. soap, sunscreen and detergents); and
- impoundments.

Existing controls and planning regimes

A national recovery plan for the GAB discharge spring wetlands has been adopted (Fensham *et al.*, 2010) and is the primary framework for the community's recovery. The overall objective of the recovery plan is to maintain or enhance groundwater supplies to GAB discharge spring wetlands, maintain or increase habitat area and health, and increase all populations of endemic organisms.

Specific actions proposed to recover the community include controlling flow from strategic bores; reviewing historic spring flows; monitoring current spring flows; controlling new groundwater allocations; protecting and managing

Category 1 and 2 GAB discharge springs through perpetual agreements; fencing appropriate springs to exclude stock; controlling feral animals; preventing further spread of gambusia (a fish) and other exotic fauna; studying the interactions between native and exotic fauna; completing an inventory of endemic species in GAB springs; monitoring populations of endemic species; implementing protocols to avoid transportation of organisms from one location to another; re-establishing the natural values of reactivated springs; encouraging landholders to responsibly manage springs; increasing involvement of Indigenous custodians in spring management; raising community awareness of the importance of GAB discharge springs; developing and implementing visitor management plans for selected sites; convening a GAB springs forum; and effectively coordinating and reporting on the recovery program (Fensham *et al*., 2010).

In Queensland, the GAB spring wetlands (irrespective of whether they are recharge or discharge) are protected as Of Concern REs under the VM Act.

Threatened flora

Literature review

A literature review for threatened terrestrial flora species from the EPA's Wildnet database, the Queensland Herbarium's Herbrecs, Corveg database, the EPBC Act Protected Matters database and relevant literature was conducted for the dam and pipeline study areas.

Field surveys

No EPBC listed threatened flora were recorded within any part of the Project impact area. Flora surveys undertaken by Chenoweth (2008) identified two listed threatened flora species within the broader dam study area. The vulnerable Ooline (*Cadellia pentastylis*) was recorded north of Taroom outside the water storage area. The vulnerable Hairy Joint Grass (*Arthraxon hispidus*) was recorded from GAB spring wetlands located outside the water storage area.

Likelihood of occurrence

The results of the assessment for likelihood of occurrence in the Project area are provided in Table 28-8. Threatened flora records are shown on Figure 28-11 for the dam study area and Figure 28-12 for the pipeline corridor.

Table 28-8 Likelihood of occurrence of threatened flora species in the Project area

Likelihood of Occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Likelihood of Occurrence Explanatory Notes	Index of Confidence
DAM IMPACT AREA					
Likely	*Arthraxon hispidus* Hairy Joint Grass	V	EPBC, HE, RF/BW	The species *Arthraxon hispidus*, was recorded in GAB Spring Communities 1, 4, 6 22-25, 27, 30, 32, 59 and 60 by Fensham & Wilson (1997). It was recorded again during the current study in the vicinity of GAB Spring Communities 1 and 27 (Chenoweth 2008).	High

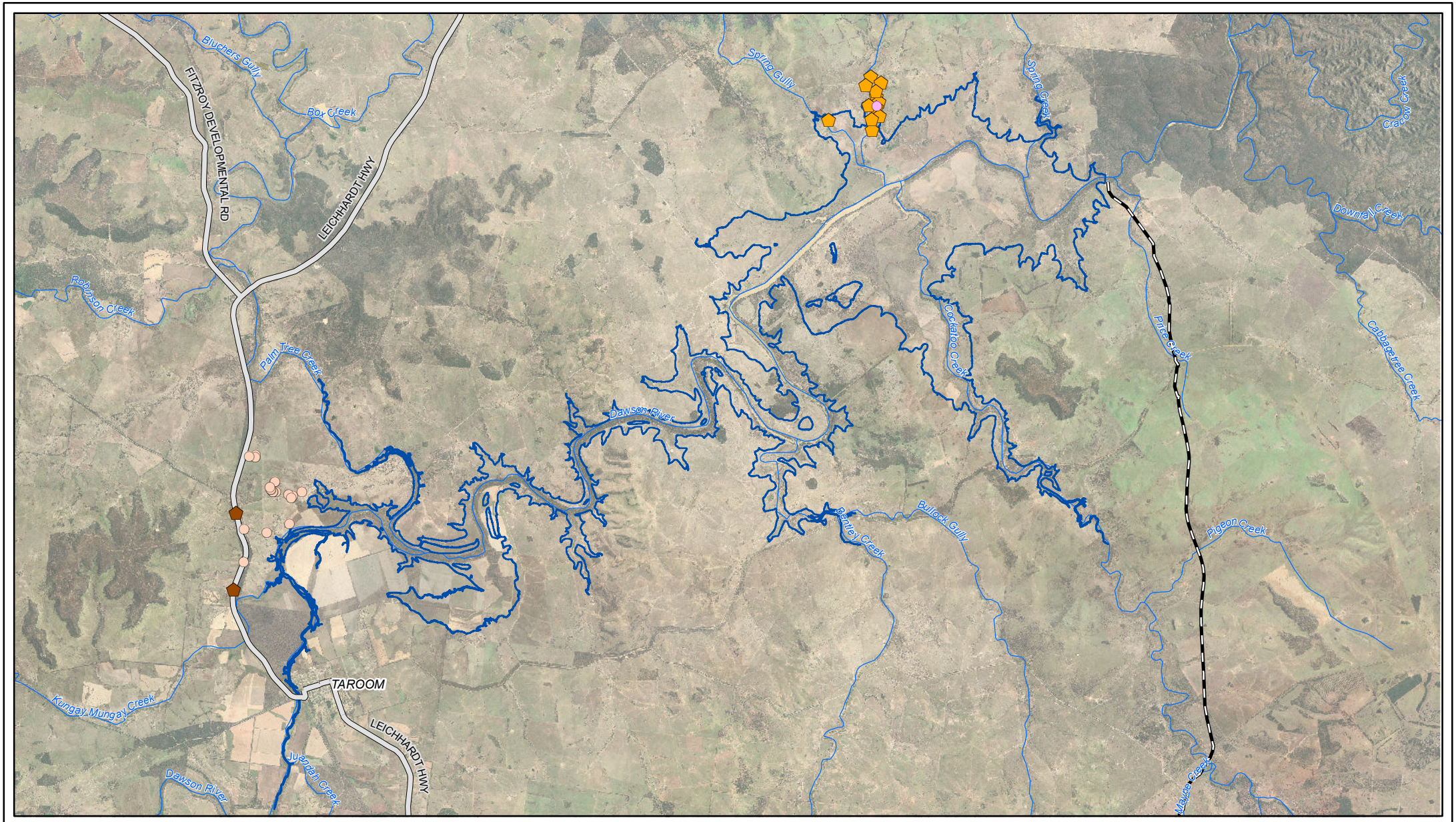
Likelihood of Occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Likelihood of Occurrence Explanatory Notes	Index of Confidence
Possible	*Prostanthera* sp. (Dunmore D.M. Gordon 8A)	V	H	No survey records. Potential to occur in RE 11.3.21.	Medium
Unlikely	*Commersonia argentea (syn. Commersonia sp. Cadarga (G.P.Guymer 1642))*	V	EPBC	No survey records. Suitable habitat does not occur within the Project area.	Medium
Unlikely	*Dichanthium queenslandicum* King Blue-grass	V	EPBC	No survey records. Suitable habitat does not occur within the Project area.	Medium
Unlikely	*Digitaria porrecta* Finger Panic Grass	E	EPBC	No survey records.	High
Unlikely	*Eriocaulon carsonii*	E	EPBC	Recorded during the field survey associated with GAB springs along Cockatoo Creek. Located well outside the Project area.	High
Unlikely	*Zieria verrucosa*	V	H	No survey records. Suitable habitat does not occur within the Project area.	Medium
Absent	*Cadellia pentastylis* Ooline	V	EPBC, W	Detailed searches located several specimens outside of the Project area to the north of Taroom. Thorough searches within the water storage did not locate any specimens or suitable habitat.	High
Absent	*Eucalyptus beaniana*	V	H	No survey records. Range does not extend to the study area.	High
PIPELINE EASEMENT					
Likely	*Acacia curranii* Curly-bark Wattle	V	W	No survey records but potential habitat occurs in pipeline easement.	Medium
Possible	*Calytrix gurulmundensis* Gurulmundi Fringe Myrtle	V	W	No survey records. Potential to occur in eucalypt associations to the north of Miles.	Medium
Possible	*Commersonia argentea*	V	EPBC	No survey records. Potential to occur in eucalypt associations to the north of Miles.	Medium
Possible	*Denhamia parviflora* Small-leaved Denhamia, Thorny Pea	V	W	Although the pipeline avoids softwood scrub communities some vine forest species occur in association with Brigalow communities which occur in the pipeline corridor.	Medium
Possible	*Digitaria porrecta* Finger Panic Grass	E	EPBC, W	Mapped within grassland ecosystems (RE 11.9.12) nearby. It is possible the species may occur in non remnant grasslands.	Medium

Likelihood of Occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Likelihood of Occurrence Explanatory Notes	Index of Confidence
Possible	*Diuris tricolor (Diuris sheaffiana)* Tricolour Diuris, Tricolour Donkey-orchid	V	W, EPBC	No survey records. Potential to occur in eucalypt associations to the north of Miles.	Medium
Possible	*Homopholis belsonii*	V	W, EPBC	No survey records. Potential to occur in road reserves under Brigalow.	Medium
Possible	*Philotheca sporadica*	V	W	No survey records. Potential to occur in eucalypt associations to the north of Miles.	Medium
Possible	*Pterostylis cobarensis* Cobar Greenhood Orchid	V	W	No survey records. Potential to occur in eucalypt associations to the north of Miles.	Medium
Unlikely	*Acacia handonis* Percy Grant wattle	V	W	Known only from Barakula State Forest.	Medium
Unlikely	*Arthraxon hispidus* Hairy Joint Grass	V	W, EPBC	No survey records. Suitable habitat absent from pipeline easement.	Medium
Unlikely	*Cadellia pentastylis* Ooline	V	W	Suitable habitat does not occur in the pipeline easement.	Medium
Unlikely	*Dichanthium queenslandicum* King Blue Grass	V	EPBC	As the pipeline easement will avoid natural grasslands it is unlikely that this species would be encountered.	Medium
Unlikely	*Eucalyptus argophloia* Qld Western White Gum	V	W (bp)	No survey records. Has a restricted distribution in a small to the north of Chinchilla.	Medium
Unlikely	*Floydia praealta* Ball Nut	V	W	No survey records. Suitable habitat absent from pipeline easement.	Medium
Unlikely	*Homoranthus decumbens*	V	W	Specific habitat requirements do not occur in the pipeline easement.	Medium
Unlikely	*Rhaponticum australe* Austral Cornflower	V	EPBC	As the pipeline will avoid natural grasslands it is unlikely that this species would be encountered.	Medium
Unlikely	*Thesium australe* toadflax	V	W, H	Recorded in grasslands located outside of, but in proximity to, the pipeline easement. As the pipeline will avoid natural grasslands it is unlikely that this species would be encountered.	High

E= Endangered; V= Vulnerable.

W = Wildnet; H = Herbrecs database (EPA, 2005a; DERM, 2009a); Corveg = EPA (2000); HE= Dowling & Halford (2007); Ison = Ison Environmental Planners (1996); RF/BW = Fensham and Wilson (1997);

EPBC = EPBC Protected Matters Search (for the dam study area the search polygon was defined by the following four corners: 149 43 38, -25 21 25;150 13 6, -25 21 16;150 12 49, -25 39 54; and 149 44 3, 25 40 27; for the pipeline study area the search polygon was defined by the following lines with a 300 m buffer: -25.49083, 150.1327; -25.46672, 150.0341 and -26.81, 150.75; -25.26, 151.37); NMRW = NMRW (2008) Essential Habitat Mapping; and REDD = Regional Ecosystem Description Database, EPA (2007).



LEGEND

- Towns
- Pipeline Route
- State Controlled Roads
- Watercourses
- Other Infrastructure
- Full Supply Level (183.5m AHD)

Higher Precision Records from External Sources

- *Arthraxon hispidus*
- *Digitana porrecta*
- *Eriocaulon carsonii*
- *Thesium australe*
- *Cadellia pentastylis*

Species Recorded by CEPLA (2008)

- *Arthraxon hispidulis*
- *Cadellia pentastylis*
- *Eriocaulon carsonii*

Projection: GDA94 Zone 56

Figure 28-11

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Location of threatened flora species - dam study area

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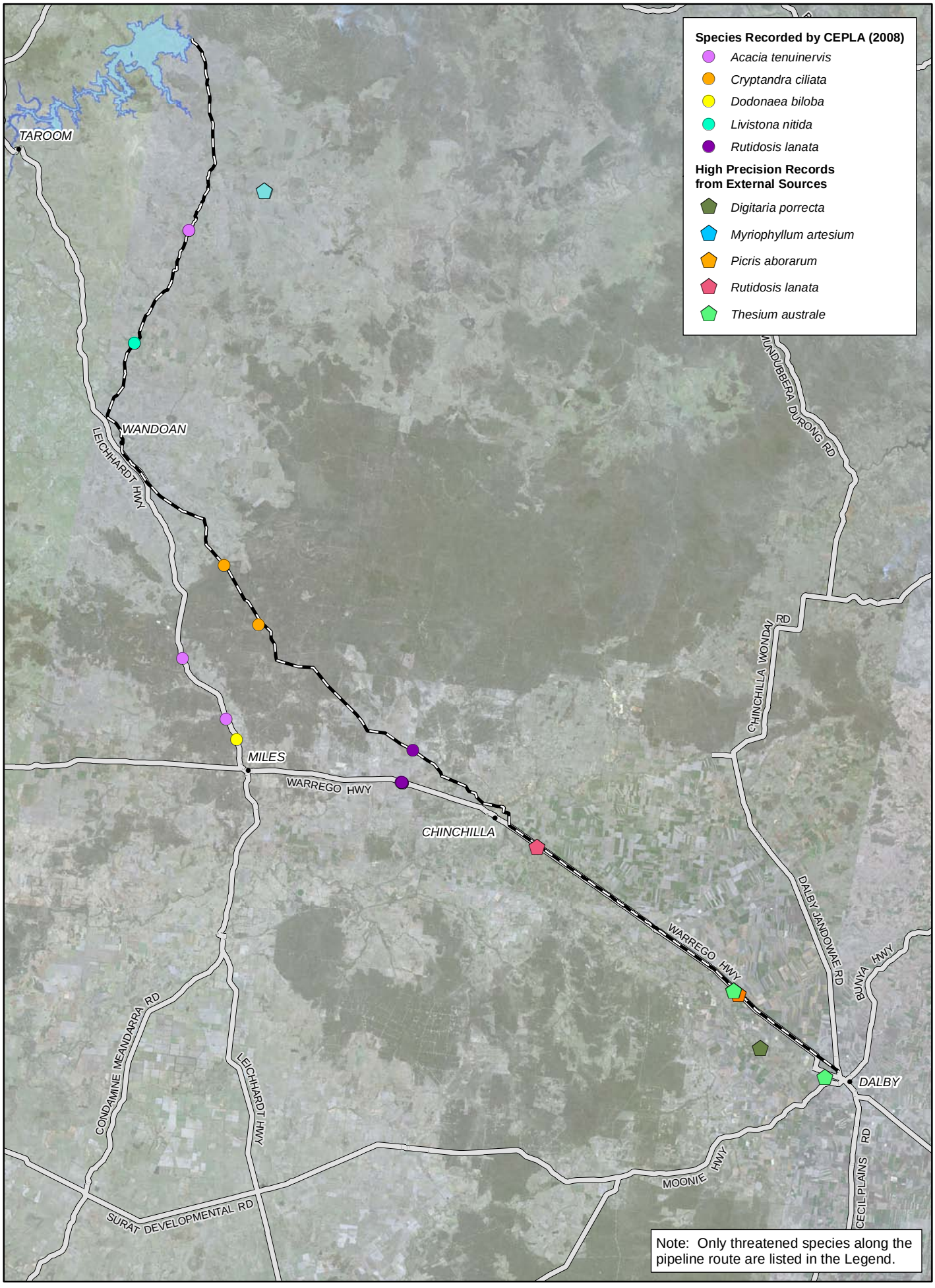


LEGEND

- Town
- Pipeline Route
- State Controlled Roads
- Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 28-12

0 5 10 20
Kilometres

N

Scale 1:900,000 (at A4)

NATHAN DAM AND PIPELINES EIS

Location of threatened flora species - pipeline

I:\QENV2\Projects\QE40192\400 - Nathan - Spatial\ArcMXD\Figures\280_MNES\Figure_28-12_Threatened_Flora_Species_Pipeline_Route.mxd Produced: 28/06/2011

Threatened flora species which are known or likely occurrences in the Project area are described below and have been assessed under the EPBC Act Significant Impact Guidelines in Section 28.4.2.2.

- Hairy-joint Grass (*Arthraxon hispidus*)

Current distribution

Hairy-joint Grass has a wide distribution overseas from tropical Africa to Asia. In Australia, the species has been recorded from scattered locations throughout Queensland and on the northern tablelands and north coast of NSW (TSSC, 2008ig).

Ecology

Hairy-joint grass (Family Poaceae) is a slender tufted creeping grass that roots at the nodes, with erect to semi-erect stems. In NSW and Queensland, hairy-joint grass is found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps, as well as woodland. In south-east Queensland, hairy-joint grass has also been recorded growing around freshwater springs on coastal foreshore dunes, in shaded small gullies, on creek banks, and on sandy alluvium in creek beds in open forests, and also with mosses in mound springs (TSSC, 2008ig).

Populations within the area affected by the proposed action

Hairy-joint grass was recorded by Fensham and Wilson (1997) in spring 24 in RE 11.3.22, which is located just outside FSL. During the field survey for the EIS it was also recorded in springs 1 and 27 in RE 11.3.22, also located outside FSL. These GAB springs will not be inundated by FSL, however, there are potential impacts from increased groundwater pressure resulting in the expansion of wetland areas. This species is a likely occurrence in other GAB spring wetlands located within FSL.

Current pressures

The listing advice for the species identifies the main threats to hairy-joint grass being grazing and trampling by stock, inappropriate fire regimes and competition from introduced grasses (TSSC, 2008ig).

Existing controls and planning regimes

Hairy-joint Grass is listed as a vulnerable species under the EPBC Act and also Queensland legislation.

Management Plans relevant to the species include the Carnavon National Park Plan of Management (TSSC, 2008ig).

- Curly-bark Wattle (*Acacia curranii*)

Current distribution

Curly-bark Wattle is known from three separate areas; Lake Cargelligo in NSW, Gunderbooka Range near Bourke in NSW and Gurulmundi State Forest in Queensland (TSSC, 2008gt). Gurulmundi State Forest is located approximately 15 km west of the pipeline route, approximately 20 km north of Miles.

Ecology

Curly-bark Wattle is an erect or spreading multi-stemmed shrub growing to 4 m tall, with distinctive red curling bark (TSSC, 2008gt). It prefers acidic, skeletal soils in rocky habitats and occupies specialised habitats comprising rocky

ridges and deeply weathered sandstone. It regenerates from root suckers after fire, with fire disturbance also said to contribute to seedling establishment (DEC NSW, 2010).

Populations within the area affected by the proposed action

Curly-bark Wattle was not recorded during the field survey, but this species is a likely occurrence within the pipeline easement due to the presence of suitable habitat (REs 11.3.1, 11.4.3, 11.9.1, 11.9.4, 11.9.5 and 11.9.6), and its vicinity to Gurulmundi State Forest approximately 15 km west of the pipeline where a population of this species occurs.

Current pressures on species

The main identified threats to curly-bark wattle are habitat erosion; grazing, browsing and horning of adult and seedling plants by feral goats (*Capra hircus*); grazing by stock, rabbits (*Oryctolagus cuniculus*), and macropods; clearing of vegetation for fire trail widening; quarrying activities at the Lake Cargelligo and Gurulmundi sites; predation of seeds by insects causing a large number of seeds to be non-viable; and lack of suitable fire disturbance for seedling establishment (TSSC, 2008gt).

Existing controls and planning regimes

Curly-bark Wattle is listed as a vulnerable species under the EPBC Act and under Queensland legislation.

Threatened fauna

Literature review

A literature review for threatened terrestrial fauna from DERM's Wildnet database, the Birds Australia database, the EPBC Act Protected Matters database and relevant literature was conducted for the dam and pipeline study areas.

Field survey

A total of 216 species of vertebrate fauna were recorded during the March and July 2008 surveys within the dam study area, comprising 16 amphibians, 37 reptiles, 125 birds, 21 non-flying mammals and 17 bats. A total of 51 species of vertebrate fauna were observed along the pipeline route during the 2008 and 2010 surveys including one frog, nine reptiles, 38 birds and two mammals.

Three listed threatened fauna species under the EPBC Act were recorded during the field surveys:

- Squatter Pigeon (southern) (*Geophaps scripta scripta*);
- Brigalow Scaly-foot (*Paradelma orientalis*); and
- Boggomoss Snail (*Adclarkia dawsonensis*).

Squatter Pigeon and Boggomoss Snail were recorded within the water storage area. Brigalow Scaly-foot was recorded in Callitris woodland to the north-east (outside) of the water storage area. Surveys of the pipeline corridor did not identify any listed threatened species. Threatened fauna records are shown on Figure 28-13 for the dam study area.

Likelihood of occurrence

The assessment of the likelihood of occurrence in the Project area is provided in Table 28-9.

Table 28-9 Likelihood of occurrence of threatened fauna species within the Project area

Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
DAM IMPACT AREA					
Invertebrates					
Known	*Adclarkia dawsonensis* Boggomoss Snail	CE		Field surveys suggest that the Boggomoss Snail is confined to the alluvial flats and riparian environments between Taroom and Theodore (BAAM 2008).	Species has been positively recorded in the Project area. One sub-population known from three boggomosses at Mt Rose Station (near Glebe Weir) and one subpopulation known from five riparian sites along the Dawson River downstream of Glebe Weir.
Reptiles					
Likely	*Paradelma orientalis* Brigalow Scaly-foot	V		Restricted to the brigalow belt but found in a wide variety of open forest habitats (Schultz and Eyre 1997; Tremul 2000). Suitable habitat for Brigalow Scaly-foot includes open-forests to woodlands in regional ecosystems on Land Zones 3, 4, 5, 7, 8 (near the periphery of LZ 10), 9 and 10 (SEWPAC, 2011a).	Available habitat which is proximal to and buffering a known occurrence recorded from Callitris woodland on sand to the north of the dam wall site, but outside the impact area. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species is known/likely within the Project area (SEWPAC, 2011a).
Likely	*Rheodytes leucops* Fitzroy River Turtle	V		Endemic to Fitzroy Basin. Prefers fast flowing, clear water associated with riffle zones connected by large, deep pools.	Available habitat which is proximal to and buffering a known occurrence of a population. There are records of the Fitzroy River Turtle in the Dawson River below Orange Creek Weir (approximately 45 km downstream of Glebe Weir and above and below Theodore Weir, approximately 128 km downstream of Glebe Weir (Limpus *et al*., 2007).
Possible	*Denisonia maculata* Ornamental Snake	V		Occurs in brigalow woodland, riparian woodland, and open forest growing on natural levees (Shine 1983; Cogger *et al*. 1993). Shows a preference for moist areas (Wilson and Knowles 1988).	No observations or Wildlife Online records. Suitable habitat occurs within the impact area and is within normal distribution range of this species. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow

Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
					Belt Reptiles shows the species may occur within the Project area (SEWPAC, 2011a).
Possible	*Egernia rugosa* Yakka Skink	V		Factors limiting distribution are poorly known. Occurs in dry sclerophyll forest or woodland and rocky areas where it lives in communal burrow complexes, often under heaped dead timber, and in deep rock crevices; often uses rabbit warrens and has also been recorded under shearing sheds and other rural buildings. Its presence may be recognised by communal defecation site (Wilson 2005; Cogger, *et al* 1993).	No observations or Wildlife Online records. Suitable habitat exists within the impact area however may be suboptimal. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species may occur within the Project area (SEWPAC, 2011a).
Possible	*Furina dunmalli* Dunmall's Snake	V		Occurs in the brigalow belt region (McDonald *et al*. 1991; Cogger *et al*. 1993). This species is genuinely rare throughout its range with very few records.	No observations or Wildlife Online records. Suitable habitat exists within the impact area however may be suboptimal. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species may occur within the Project area (SEWPAC, 2011a).
Birds					
Known	*Geophaps scripta scripta* Squatter Pigeon (southern)	V		Inhabits a wide range of vegetation types. It prefers areas of sandy soil dissected by low gravely ridges, which have the shortest cover of grasses. Nearly always found near permanent water (Marchant and Higgins 1993).	Species has been positively observed in the Project area within woodland of Dawson River and GAB springs in the impact area. Likely to occur in woodland areas which support good cover of native grasses.
Likely	*Rostratula australis* Australian Painted Snipe	V		Inhabits freshwater and brackish wetlands, including flooded grasslands, Melaleuca swamps and saline sedgelands.	QM records exist within study area and study area is within species range. Wetlands associated with the Dawson River floodplain likely to provide seasonal habitat for this species because it contains resources capable of supporting individuals.
Unlikely	*Lathamus discolor* Swift Parrot	E		Inhabits dry open, box–ironbark forests and woodlands. In Queensland it is often associated with stands of mature	Study area is on the northern limit of migratory range and therefore habitat within study area is considered unsuitable

Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
				Queensland blue gum (*Eucalyptus tereticornis*).	based on consideration of literature and field knowledge. No observations or Wildlife Online records.
Unlikely	*Neochmia ruficauda ruficauda* Star Finch (eastern)	E		Inhabits tall grass and reed beds associated with swamps and watercourses. It may also be found in grassy woodlands, open forests and mangroves. The condition of this habitat varies according to season, grazing pressure and fire. It is considered to be regionally extinct within the BBS Bioregion. (EPA 2002a). The total population is estimated to consist of 50 individuals (Higgins et al. 2006) or it may be possibly extinct (Garnett et al. 2005).	Some suitable habitat may occur within impact area, however vegetation is unlikely to support this species because no observations were made during field surveys or on Wildlife Online records.
Unlikely	*Turnix melanogaster* Black-breasted Button-quail	V		Inhabits dry rainforest, vine scrub and lantana thickets, (Marchant and Higgins 1993).	Vegetation is unlikely to support this species as no intact areas of dry vine thicket occur in the impact area. No observations or Wildlife Online records.
Mammals					
Possible	*Chalinolobus dwyeri* Large-eared Pied Bat	V		Inhabits low to mid-elevation dry open forest and woodland close to preferred roosting sites which include caves.	Suitable habitat may exist in caves in the Dawson Ranges (not in impact area), however may be known to be suboptimal as there were no observations or records within study area.
Possible	*Dasyurus hallucatus* Northern Quoll	E		Inhabits a variety of habitats across its current range including rocky areas, eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrublands, grasslands and deserts. Usually requires rocky areas or structurally diverse woodland for denning / shelter purposes with surrounding vegetated habitats used for foraging and dispersal (SEWPAC, 2011b). In Queensland, the species occurs from the south east to the gulf of Carpentaria (SEWPAC, 2011b).	Suitable habitat occurs within the impact area which is potentially important, however may be known to be suboptimal as there were no observations or Wildlife Online records for this species. Modelled distribution of this species in the EPBC Act Referral Guidelines for the Northern Quoll shows the species may occur within the Project area (SEWPAC, 2011b).

Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
Possible	*Nyctophilus corbeni*[2] Sout-eastern Long-eared Bat	V		Occurs in callitris/ironbark/box open forest and buloke woodland in southern Queensland (EPA 2002a).	Species not detected during field surveys but recorded in the surveys of the Lower Dawson River Floodplain (Venz *et al*., 2002). However this species was placed in the "status uncertain" category due to indistinguishable Anabat call record. Therefore this record is not confirmed. Suitable habitat occurs in the study area however may be known to be suboptimal.
Unlikely	*Hipposideros semoni* Semon's Leaf-nosed Bat	E		Poorly studied species, inhabiting rainforest and savannah woodland (Menkhorst and Knight 2001).	The study area is beyond known distribution of the species. Vegetation is unlikely to support the species because there were no reported sightings of individuals during field surveys.
Unlikely	*Petrogale penicillata* Brush-tailed Rock Wallaby	V		Inhabits rock piles and cliffs with numerous crevices and ledges in vegetation ranging from rainforest to dry sclerophyll forest (Menkhorst and Knight 2001).	Does not occur in study area as vegetation is unlikely to support the species. Historical records indicate confusion with Herbert's Rock Wallaby.
Unlikely	*Pteropus poliocephalus* Grey-headed Flying Fox	V		Forages through a variety of eucalypt forests and woodlands, where preferred flowering and fruiting plants are available. Occurs along the east-coast of Australia.	The study area is beyond the distribution of this species. Vegetation is unlikely to support the species because there were no reported sightings of individuals during field surveys.
PIPELINE EASEMENT					
Reptiles					
Likely	*Paradelma orientalis* Brigalow Scaly-foot	V		Inhabits a wide variety of open forest habitats (Schultz and Eyre 1997; Tremul 2000). Suitable habitat for Brigalow Scaly-foot includes open-forests to woodlands in regional ecosystems on Land Zones 3, 4, 5, 7, 8 (near the periphery of LZ 10), 9 and 10 (SEWPAC, 2011a).	Species was not detected during field surveys but Wildlife Online record in proximity. Suitable habitat exists within road reserves containing large Brigalow patches. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species is known/likely within the pipeline (SEWPAC, 2011a).
Possible	*Denisonia maculata* Ornamental Snake	V		Occurs in brigalow woodland, riparian woodland, and open forest growing on natural levees.	No observations or records within the study area. Suitable habitat occurs within the mid and northern

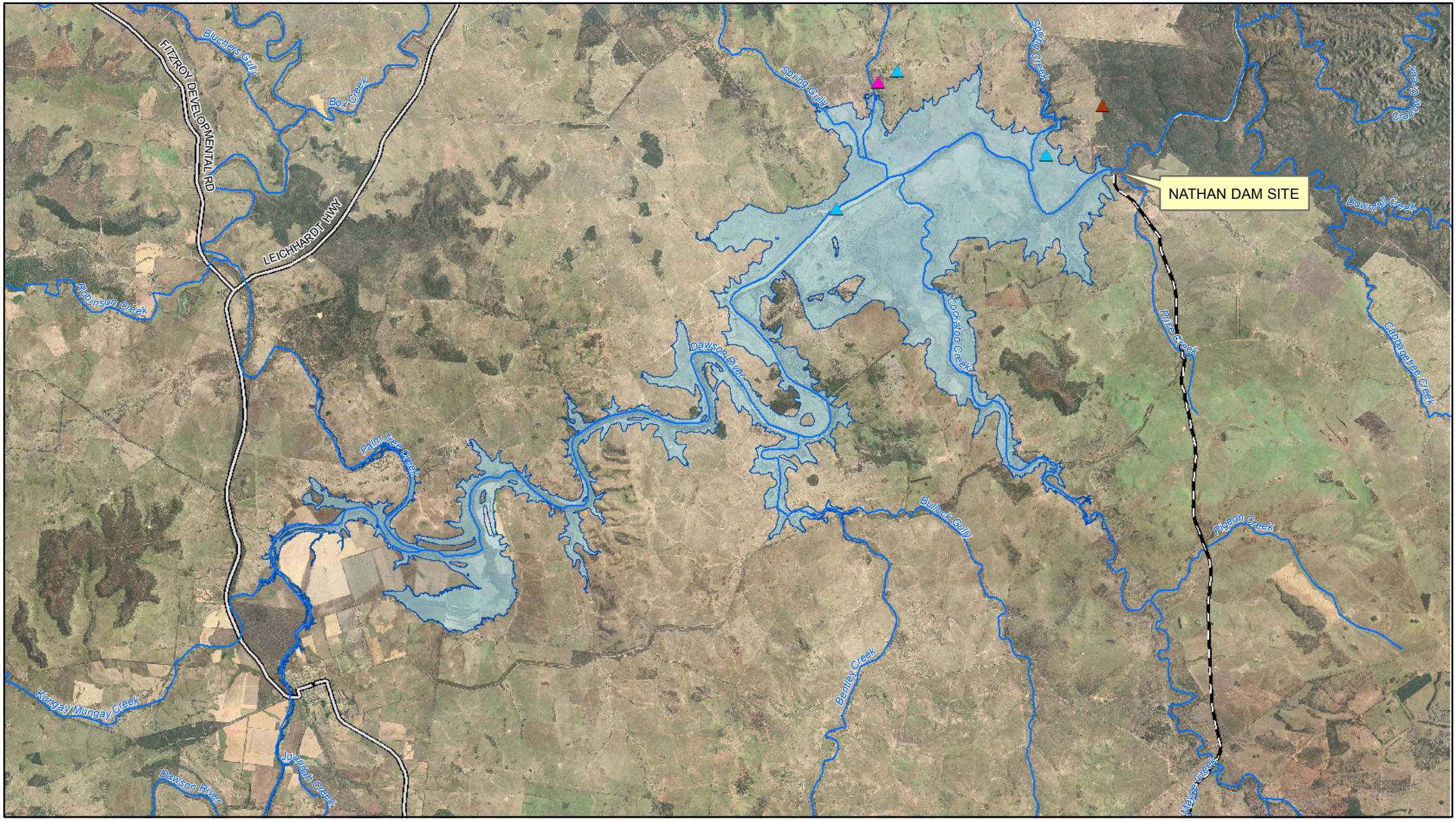
Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
					sections of the pipeline corridor and is within normal distribution range of this species however may be suboptimal. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species may occur within the pipeline (SEWPAC, 2011a).
Possible	*Egernia rugosa* Yakka Skink	V		Inhabits dry sclerophyll forest or woodland and rocky areas where it lives in communal burrow complexes, often under heaped dead timber, and in deep rock crevices.	No observations or records within the study area. Suitable habitat exists within the mid section of the pipeline corridor however may be known to be suboptimal. Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species may occur within the pipeline (SEWPAC, 2011a).
Possible	*Furina dunmalli* Dunmall's Snake	V		Inhabits brigalow, belah and cypress pine communities on heavy soils.	No observations or records within the study area. Suitable habitat exists within the mid section of the pipeline corridor however may be known to be suboptimal.
Possible	*Anomalopus mackayi* Five-clawed worm skink	V		Restricted to a small number of natural temperate grassland sites dominated by native grasses.	No observations or records of within the study area. Known sites for this species north of Toowoomba are relatively extensive native grasslands but none along route. Road reserves within the southern section of the pipeline corridor contains potential habitat for this species however may be known to be suboptimal.
Unlikely	*Tympanocryptis pinguicolla* Grassland Earless Dragon	E		Restricted to a small number of natural temperate grassland sites to the southwest of Toowoomba.	Despite extensive searches in recent years, there have been no reported sightings. The distribution of the species has not been extended and does not include the pipeline corridor.
Birds					
Likely	*Geophaps scripta scripta* Squatter Pigeon (southern)	V		Inhabits a wide range of vegetation types, nearly always near permanent water (Marchant and	Recorded in the dam study area. Species is likely to occur in woodland areas next to water which support good cover of native

Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
				Higgins 1993).	grasses along the pipeline corridor.
Likely	*Rostratula australis* Australian Painted Snipe	V		Inhabits freshwater and brackish wetlands, including flooded grasslands, melaleuca swamps and saline sedgelands.	Study area is within species range and QM records in proximity. Well vegetated wetlands associated with river floodplains are likely to provide seasonal habitat for this species.
Possible	*Erythrotriorchis radiatus* Red Goshawk	V		Requires large tracts of habitat which include productive riparian and floodplain zones. Also requires large trees for nesting, frequently the tallest and most massive in a tall stand, and nest trees are invariably within one km of permanent water.	No observations or Wildlife Online records. Riparian vegetation within Barakula State Forest (SF) and other SFs and throughout the mid section of the pipeline corridor may provide suitable habitat which potentially important however may be known to be suboptimal.
Possible	*Lathamus discolor* Swift Parrot	E		Inhabits dry open, box–ironbark forests and woodlands.	Study area is on the northern limit of migratory range, although potential habitat occurs along large waterways in the southern section of the pipeline corridor. No database records in proximity.
Unlikely	*Turnix melanogaster* Black-breasted Button-quail	V		Inhabits dry rainforest, vine scrub and lantana thickets (Marchant and Higgins 1993).	Mapped remnant vine thickets occur within the study area however, these habitats do not occur along the pipeline corridor and therefore is not considered suitable for this species.
Unlikely	*Neochmia ruficauda ruficauda* Star Finch (eastern)	E		Inhabits tall grass and reed beds associated with swamps and watercourses. It is considered to be regionally extinct within the BBS Bioregion. (EPA 2002a). The total population is estimated to consist of 50 individuals (Higgins et al. 2006) or it may be possibly extinct (Garnett et al. 2005).	Some suitable habitat occurs within study area, however is not likely to support the species as there are no database records of this species.
Mammals					
Possible	*Nyctophilus corbeni*[2] South-eastern Long-eared Bat	V		Occurs in callitris/ironbark/box open forest and bulloak woodland in southern Queensland (EPA 2002a).	Species not detected during field surveys but recorded in the surveys of the Lower Dawson River Floodplain (Venz *et al*., 2002). However this species was placed in the "status uncertain" category due to indistinguishable

Likelihood of occurrence	Scientific Name Common Name	EPBC Act Status	Reference of Record	Habitat Preferences	Likelihood of occurrence explanatory notes
					Anabat call record. Therefore this record is not confirmed. Suitable habitat occurs in the study area however may be known to be suboptimal.
Possible	*Chalinolobus dwyeri* Large-eared Pied Bat	V		Low to mid-elevation dry open forest and woodland close to preferred roosting sites which include caves.	Suitable habitat may exist in caves in the Dawson ranges and other areas of remnant vegetation, however may be known to be suboptimal. No observations or database records in proximity of pipeline corridor.
Possible	*Dasyurus hallucatus* Northern Quoll	E		Inhabits a variety of habitats across its current range including rocky areas, eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrublands, grasslands and deserts. Usually requires rocky areas or structurally diverse woodland for denning / shelter purposes with surrounding vegetated habitats used for foraging and dispersal (SEWPAC, 2011b). In Queensland, the species occurs from the south east to the gulf of Carpentaria (SEWPAC, 2011b).	Suitable habitat occurs within study area within large habitat patches such as Barakula SF, however may be known to be suboptimal. No observations or database records in vicinity of pipeline corridor.
Unlikely	*Pteropus poliocephalus* Grey-headed Flying Fox	V		Forages through a variety of eucalypt forests and woodlands, where preferred flowering and fruiting plants are available. Occurs along the east-coast of Australia.	Vegetation is unlikely to support the species as study area falls outside of known distribution which is along the coast (east of the Great Dividing Range).
Unlikely	*Hipposideros semoni* Semon's Leaf-nosed Bat	E		Foraging habitat includes rainforest and savannah woodland (Menkhorst and Knight 2001).	Vegetation is unlikely to support the species as study area is beyond known distribution of the species. No observations or records in the study area.
Unlikely	*Petrogale penicillata* Brush-tailed Rock Wallaby	V		Inhabits rock piles and cliffs with crevices and ledges (Menkhorst and Knight 2001).	Vegetation is unlikely to support the species as there were no observations, database records or habitat in the study area.

1 Status: EPBC = *Environment Protection and Biodiversity Conservation Act 1999* NC = *Nature Conservation (Wildlife) Regulation 2006,*
CE = Critically Endangered; E = Endangered; V = Vulnerable; NT = Near Threatened

2 Previously known as *Nyctophilus timoriensis*



LEGEND

- Town
- Proposed Pipeline
- Major Road
- Watercourses
- Full Supply Level (183.5m AHD)

Significant Fauna Locations

- Brigalow Scaly-foot
- Short-necked Worm-skink
- Squatter Pigeon

Projection: GDA94 Zone 56

Figure 28-13

0 2 4 Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Location of threatened fauna - dam and surrounds

I:\QENV2\Projects\QE40192\400 - Nathan - Spatial\ArcMXD\Figures\280_MNES\Figure_28-13_Location_Threatened_Fauna_Dam_Surrounds_v2.mxd Produced: 22/12/2011

Threatened fauna species which are known or are likely occurrences in the dam and pipeline study areas have been assessed under the EPBC Act Significant Impact Guidelines in Section 28.4.2.2.

Boggomoss Snail

Current distribution

Boggomoss Snail is found in the Taroom area of south-eastern Queensland. It occurs in the Dawson Valley, north-east of Taroom, on the Dawson River (Stanisic, 1996; 2008). In light of recent findings as part of this EIS there is a need to update the distributional information relating to this species in the DEWHA Species Profile and Threats (SPRAT) database, as well as the Recovery Plan.

Ecology

Boggomoss Snails are found in the moister riparian (riverside) and some boggomoss habitats on alluvial flats between Taroom and Theodore (Stanisic, 2008). Most of this habitat has been cleared for farming and little original vegetation remains (Clarke & Spier-Ashcroft, 2003).

At Mt Rose Station the snail is found associated with GAB spring wetlands (locally known as boggomosses). Boggomosses are a series of small, raised peat bogs that form when water from aquifers of the GAB is pushed to the surface through mound springs. The vegetation is dominated by water-tolerant species, such as Coolabah (*Eucalyptus coolabah*), sedges, ferns and mosses (Clarke & Spier-Ashcroft, 2003; Noble *et al*., 1998). At the boggomoss sites the snail lives under deep, moist accumulated leaf litter and fallen timber but no restriction to particular tree species was noted (BAAM, 2009). It should be noted that comparatively few Boggomoss sites are actually suitable for the Boggomoss Snail. The species has been recorded at only three out of some 30 boggomosses mapped in the Dawson River Valley.

Along the Dawson River the Boggomoss Snail has been recorded from 14 sites within 11 discrete riparian habitat patches, within open to closed forests of Queensland Blue Gum (*Eucalyptus tereticornis*) and Carnarvon Palm (*Livistona nitida*). Within these forests, the Boggomoss Snail was recorded either under deep leaf litter at the base of Queensland Blue Gums, Carnarvon Palms, Sandpaper Figs (*Ficus opposita and F. coronata*) and Green Kamala (*Mallotus cloaxyloides)*, under deep accumulations of palm fronds or at the base of Carnarvon Palms and under rotting logs, where moisture accumulates due to the drainage structure of the fronds and leaves.

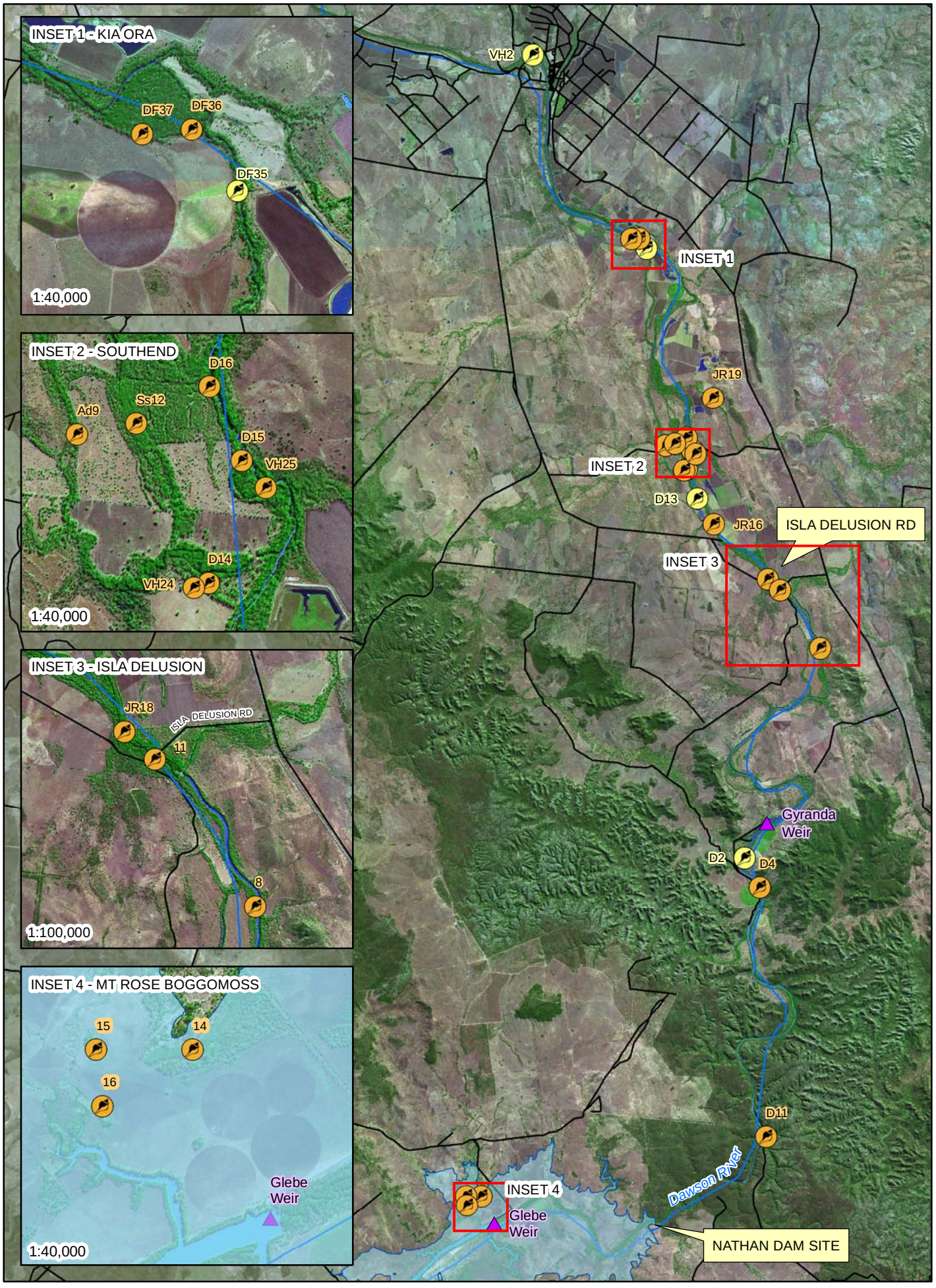
The life history of the Boggomoss Snail is unknown. Stanisic (2008) suggests that the species may have a similar lifespan (10–20 years) to that of other land snails in arid northern Australia. It is suggested that Boggomoss Snail reach maturity in their second year (BAAM, 2009) with the number of reproducing adults in any population critical to the viability of that population (JKR Ecological, 2010). The Boggomoss Snail is known to aestivate (hibernate) in very dry periods (Stanisic, 2008). It seals on to logs and other debris with a very weak mucus seal which breaks easily when disturbed. Hence the snail is often found lying free in the litter or under logs and this led to the earlier erroneous conclusion that it was a free sealer (J. Stanisic pers. comm.) It is assumed that the Boggomoss Snail feeds on decaying plant matter, bacteria and fungi (JKR Ecological, 2010) like many other land snails (Bishop, 1981; cited in Clarke & Spier-Ashcroft, 2003).

Populations within the area affected by the proposed action

A series of surveys have been undertaken to assess the distribution and population size of the Boggomoss Snail in the region. In summary, a total of 187 sites in the Dawson River catchment have been surveyed between 2008 and 2010 through the collective efforts of BAAM, SKM and JKR Ecological. This has covered most potential habitat sites within the region, though some areas of potential habitat on private property have not been assessed. The species (live snails) has been recorded from 17 sites, increased from the original two sites identified in the Recovery Plan for the species (Stanisic, 2008). The distribution of records (showing both live snails and shells) is illustrated in Figure 28-14.

Population estimates have been obtained for six sites at which breeding occurs; Mt Rose Station, Isla-Delusion Camping Reserve, Southend Station (x 3 sites) and Gyranda. Breeding was denoted by the presence of live juvenile and adult snails. With the exception of Mt Rose, these sites all occur within the Dawson River riparian zone downstream of Nathan Gorge. The Mt Rose and Dawson River sites are likely to comprise two distinct subpopulations because of their isolation from each other and their limited chances of reconnection. They were probably part of the same population prior to clearing of the land for farming. The Mt Rose subpopulation is made up of three sites associated with three separate GAB spring wetlands. The Dawson River subpopulation is made up of five sites at Isla-Delusion Camping Reserve, Southend Station (x 3) and Gyranda. Although separate, these sites are connected by the Dawson River riparian corridor and are therefore likely to have genetic exchange during flooding.

Population estimates for breeding sites are provided in Table 28-10. The Mt. Rose population estimate is based on the BAAM microhabitat density. The Dawson River population estimates are based on the SKM patch-specific densities. The standard error (SE) for the dataset was applied to the population estimate to give a population range.



LEGEND

- Weir
- Roads
- Watercourse
- Full Supply Level (183.5m AHD)
- Live Snails
- Shells

Projection: GDA94 Zone 56

Figure 28-14

0 1.5 3 6
Kilometres

N

Scale 1:250,000 (at A4)

SKM SunWater Making Water Work

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Boggomoss Snail records

Table 28-10 Boggomoss Snail population estimates based on patch specific densities

Site	Area Searched (m^2)	No. live snails	Habitat Area (m^2)	Snail Density (m^2)	Population Estimate	Population Range[1]
Mt Rose (BAMM, 2009)[2]	6 micro-habitats	22	7,500 100 micro-habitats	3.66 (per micro-habitat)	350	NA[3]
Gyranda (SKM, 2009)	20	1	70,164	0.05	3,508	2,204-4,811
Isla Delusion (SKM, 2009)	100	8	143,986	0.08	11,519	8,844-14,193
Southend - Wetland (SKM, 2009)	20	6	1,073	0.3	322	302-342
Southend - Dawson River Anabranch & Wetland (JKR Ecological, 2010)	30	5	60,180	0.17	12,036	11,454–13,157
Southend – Palm Grove (SKM, 2009)	100	2	103,071	0.02	2,061	147-3,976
Population			**385,974m^2 or 38.59 ha**		**29,796**	**22,951-36,479[4]**

1 Population range based on population estimate multiplied by standard error to give a lower and upper limit

2 Population estimate for main Mt Rose boggomoss only.

3 Standard error not provided by BAAM

4 Population range does not include Mt Rose subpopulation estimate

The population estimate for the Boggomoss Snail has been calculated at 29,446 (standard error 22,951-36,479) for the Dawson River subpopulation and 350 for the Mt. Rose subpopulation for which an estimate was made. Population estimates were not made for all sites where live snails were found, either because the habitat patch was too small to allow a population estimate by the SKM methodology, or the recorded snail densities were too low to allow a population estimate by the BAAM methodology. The population estimates are given separately due to the different methods used.

It is acknowledged that estimating the population size of a species that is cryptic and very patchily distributed is not precise, as indicated by the standard errors. The SKM method used was a standard sub-sampling approach but due to the different patch sizes, the sampling effort at each site was not uniform. More important than an exact population figure is the fact that the population is clearly significantly larger than originally thought and the species is far more widely distributed than originally thought (17 sites instead of 2).

The habitat preferences of the species are also broader than those considered historically. Broad habitat types in which the species currently occurs include the following:

- GAB spring wetlands with a canopy of Queensland Blue Gum and midstorey of Sandpaper Fig at Mt Rose Station;
- riparian forest associations within RE 11.3.25 on the Dawson River which support Queensland Blue Gum or River Red Gum with Carnarvon Palm as a co-dominant species in the canopy or a dominant sub-canopy species;
- monospecific stands of Carnarvon Palm on the Dawson River, including minor anabranch systems; and
- open forest of Queensland Blue Gum fringing ephemeral wetlands on the Dawson River floodplain.

These are considered to be refugial remnants of the historical core habitat of this species which has since been cleared. The microhabitat preferences of the species include under deep leaf litter at the base of Sandpaper Figs (at Mt Rose in particular), Queensland Blue Gums and Carnarvon Palms, under rotting logs and under accumulations of decaying palm fronds.

In terms of long-term population viability, the largest and most intact habitat systems occur downstream of the Isla-Delusion Crossing, particularly on the properties Lagoona (which is a part of the Isla-Delusion habitat) and Southend. A mix of adult and sub-adult snails has been reported from all of the known populations, indicating that conditions remain suitable for recruitment of individuals to those populations.

The snail surveys reaffirm the preferred habitat of the Boggomoss Snail as the black soil alluvial flats (floodplain) of the Dawson River between Taroom and Theodore. Historically, these were an extensive archipelago of habitats supporting a locally circumscribed vegetation community located between the stream-bound riparian habitats dominated by Carnarvon Palm and the drier scrubs of the surrounding hillsides (BAAM, 2008). According to the CSIRO land system maps (Specht, 1968) the Mt Rose alluvial flats were largely 'brigalow country on alluvium associated with the Dawson River'. The soils were depositional alluvium on deep cracking clays with gilgai formations. The vegetation was brigalow with some shrub understorey and associated grassland (Speck *et al.*1968). Since then, the landscape of the Dawson River floodplains has been highly modified for grazing and agriculture.

Stanisic (BAAM, 2008) suggests that these gilgaied brigalow habitats formed the historical core habitat of Boggomoss Snail. This theory is supported by the ecology of a sister species of the Boggomoss Snail (*Adclarkia* sp.) which lives in gilgaied brigalow habitats surviving in road verges in the Brigalow-Chinchilla area. This is a very similar looking snail to the Boggomoss Snail and with a very similar thin shell. The closed canopy of these brigalow communities, the associated deep accumulated litter and timber on the ground provide the necessary microhabitat for the survival of the snail. The gilgais help maintain a relatively stable moist environment because of their ability to retain moisture for extended periods after rainfall.

In this context, the Mt Rose boggomosses and stream-bound riparian habitats of the nearby Dawson River are refugial remnants of preferred habitats maintained by the moisture from the GAB springs or the riparian vegetation. It should be noted that the common name of the species is something of a misnomer because it is not restricted to boggomosses. Indeed it has only been recorded on three of the 30 or so boggomosses in the Dawson Valley. The Boggomoss and riparian habitats are considered secondary but significant habitats in the context of historical habitat loss. The Boggomoss Snail is able to survive near the boggomosses or Dawson River due to a combination of the moist environment (maintained through good ground cover and a relatively closed canopy) and the accumulation of deep litter and timber. Riparian populations are threatened by floods which scour the snail's microhabitat of accumulated litter and even drown the snails if there is extended submergence, and drying of the riparian habitat during drought (BAAM, 2010). Although to a lesser frequency, the Mt. Rose population is also threatened by occasional flooding.

The completion of the JKR Ecological (2010) study following a major flood provided an insight into population persistence in the more dynamic riparian environments of the Dawson River. Live snails were located in riparian woodland which had been inundated to a depth of at least four metres for an extended period of time, indicating that riparian populations can, and do, survive major floods and/or rely on flooding to colonise riparian habitat patches. As a

result, both the riparian and Mt. Rose populations are expected to have survived the major flood that inundated the floodplain and Mt. Rose boggomosses in January 2011.

Current pressures on the species

There are a number of existing threats to the Boggomoss Snail and these are summarised below (Stanisic, 2008).

- Predation. The large numbers of damaged shells uncovered on the Mt Rose boggomoss suggest that predation may be a significant threat to the species. A study of the damage pattern exhibited by the shells suggests that the predator is mammalian. The results of the brief trapping program conducted at the Mt Rose and Isla-Delusion sites showed that mice (*Mus musculus*) and rats (*Rattus fuscipes*) were the dominant mammals present with these species being caught in more than 50% of traps.
- Fire. Fire is a major threat. Grass growth on the main Mt Rose boggomoss is extremely high and could be easily ignited by lightning strikes. The controlled release of stock over short time periods has been used as means of reducing this threat through inhibiting grass growth.
- Flooding. In the riparian habitats, particularly at the level of the lower levee along the Dawson, and to a lesser frequency in the Mt Rose boggomosses, flooding is a perennial threat to any snails that might inhabit these areas.
- Reduced aquifer flows. Alteration to the aquifer flow which might result in a drying of the boggomoss habitat and consequent loss of vital vegetative elements is seen as a threat. Dewatering for construction of the dam wall will not affect the Mt Rose boggomosses.
- Stock grazing. Permanent trampling and grazing by stock e.g. cattle is a major threat to the Boggomoss Snail at all sites. In the long term this will result in significant habitat alteration reducing ground cover. Significantly the Mt Rose boggomosses and parts of the Isla-Delusion camping and water reserve where the Boggomoss Snail occurs are fenced. However, periodic stock grazing is beneficial in reducing the risk of grass fires.

Existing controls and planning regimes

There is an approved National Recovery Plan for the Boggomoss Snail (Stanisic, 2008) to manage and protect the Boggomoss Snail and its habitat. The plan was adopted in July 2008 and was due for interim review in July 2011. The major actions of this recovery plan include; assessing the weed problem and controlling if necessary; developing and implementing a fire risk management plan; fencing the habitat critical to the survival of the snail to exclude cattle; and protecting the habitat of the snail through a voluntary conservation agreement with the landowners. Additional knowledge and understanding of the species is required. This will be achieved by searching for additional populations of the species; determining the impact of other threatening processes; monitoring known populations of the snail; researching the genetics of the snail; and researching the ecology and life cycle of the snail. Increasing public and landholder awareness of the snail will be achieved through the media, brochures and extension activities.

The Plan notes that it should be possible to relocate snails from the boggomoss site should the dam be approved. SunWater has engaged Dr John Stanisic of Biodiversity Assessment and Management (BAAM) to prepare a Translocation Plan for the Boggomoss Snail in line with the Recovery Plan, which will aim to translocate a number of snails to alternative habitat sites outside of the Project footprint.

The Recovery Plan will need to be updated in light of recent findings from the collective survey efforts of BAAM, SKM and JKR Ecological.

Brigalow Scaly-foot

Current distribution

Brigalow Scaly-foot (legless lizard) is restricted to central-eastern Queensland occurring primarily within the Brigalow Belt Bioregion from Inglewood, north to Emerald and east to Gladstone. Modelled distribution of this species in the Draft Referral Guidelines for the Brigalow Belt Reptiles shows the species is known/likely within the Project area (SEWPAC, 2011a).

Ecology

Brigalow Scaly-foot occurs in eucalypt forest on sandstone ridges, Brigalow woodlands and vine thickets. They are found in a wide variety of open forest habitats on several soil types (Schultz and Eyre, 1997; Tremul, 2000). In some areas lizards are found in remnant Brigalow (*Acacia harpophylla*) woodland with sparse tussock grasses on grey cracking clay soils (Cogger *et al*., 1993). It shelters beneath sandstone slabs, logs, dense leaf litter and in grass tussocks (Wilson & Swan 2003). A nocturnal species, the Brigalow Scaly-foot is primarily terrestrial, however has been recorded climbing the rough bark of wattles, possibly to lick exuding sap. On Boyne Island, sap from *Acacia falciformis* forms a major portion of the diet of both adults and juveniles. Studies on captured females from Boyne Island, near Gladstone, recorded the species laying two eggs in captivity in early November with the eggs hatching in late January.

Suitable habitat for Brigalow Scaly-foot includes open-forests to woodlands in regional ecosystems on Land Zones 3, 4, 5, 7, 8 (near the periphery of LZ 10), 9 and 10 (SEWPAC, 2011a).

Populations within the area affected by the proposed action

Brigalow Scaly-foot was recorded from Cypress Pine and Ironbark woodland on coarse-grained sedimentary rocks on Spring Creek Station to the north of the dam wall site, but outside the Project area. It is a likely occurrence within Brigalow/Belah open forests and Cypress Pine/Ironbark woodlands within the water storage area and along the pipeline corridor.

Current pressures on the species

Existing populations are threatened by clearing and thinning of habitats, inappropriate management of roadside vegetation and feral animals (Red Fox, Feral Cat) (Richardson 2008).

Existing controls and planning regimes

The draft recovery plan '*Queensland Brigalow Belt Reptile Recovery Plan 2008 – 2012'* (Richardson, 2008) has been prepared for threatened reptiles within the Brigalow Belt (North and South) Bioregion. This is not currently approved by the Commonwealth Minister and expires in 2012, but recovery objectives are considered relevant in the absence of any formal recovery plan for this species. The Draft Referral guidelines for the nationally listed Brigalow Belt reptiles (SEWPAC, 2011) have also been recently released. This policy statement is intended to provide guidance to proponents on the need to refer an action to which the EPBC Act applies.

The draft recovery objectives for the Brigalow Scaly-foot are to:

- identify and protect key habitat and important populations on private and state controlled lands through the development of partnerships between relevant stakeholders;

- reduce and manage the major threatening processes affecting threatened reptiles in the Queensland Brigalow Belt;
- ensure reptile conservation is incorporated into appropriate land management decisions within all levels of government, industry and community;
- increase community participation, awareness and understanding in the conservation and management issues of threatened reptiles; and
- increase knowledge and understanding of the species and their ecology necessary to effect their conservation and management.

Fitzroy River Turtle

Current distribution

Fitzroy River turtle is endemic to the natural permanent riverine habitats of the middle and lower Fitzroy catchment (Limpus *et al.* 2007).

Ecology

Little information is available on the abundance and life history of *R. leukops* across its greater distribution. *R. leukops* occurs in flowing rivers with large deep pools with rocky, gravelly or sand substrate, connected by shallow riffles (SEWPaC, 2011). Riffle zones are an important habitat for *R. leukops*, with the home ranges of individuals typically overlapping these habitats (Tucker *et al.* 2001), possibly due to increased foraging success in these habitats (Legler & Cann 1980).

Under low flow events, or as riffle zones become seasonally ephemeral (i.e. dry completely), *R. leukops* retreat to deeper sections of pool habitats, or even isolated waterholes, adjacent to riffle zones (Limpus *et al.* 2007, Tucker *et al.* 2001). As riffle zones throughout most of the range of the Fitzroy River turtle, including in the Dawson River, are likely to be ephemeral, this species should not be considered to be a riffle zone specialist; rather, they exploit this habitat to forage for abundant food sources such as benthic invertebrates and algae during the wet season and early dry season (Limpus *et al.* 2007). This allows the turtles to take up nutrients and build fat reserves for the dry season, which is essential for preparing to breed (Limpus *et al.* 2007). Therefore, while large, slow flowing pools can support populations of the Fitzroy River turtle, they are likely to have a lower carrying capacity than reaches containing riffle zones (Limpus *et al.* 2007).

Nesting in *R. leukops* occurs between September and December (Limpus *et al.* 2007). In areas where it has been studied, there has been a poor recruitment of juveniles into the population in recent years, and the population consists primarily of ageing adults (Limpus *et al.* 2007). However, it should be noted that the population of Fitzroy River turtles in the shallow and slow-flowing Fitzroy Barrage impoundment is a well-functioning population, with several nesting banks available (Limpus *et al* 2007, frc environmental 2007b). Conversely, populations at other sites in the Fitzroy River downstream of the study area, are not functioning as well, and reproductive success is low (Limpus *et al.* 2007).

Populations within the area affected by the proposed action

To date no Fitzroy River turtles have been identified within or upstream of the Project area despite the suite of site specific survey methods employed (Appendix 13-B, C & D). The only exception being an anecdotal reference to a deceased specimen on the Glebe Weir trash track (Limpus pers. comm. 2010). There are, however, records of the

Fitzroy River turtle in the Dawson River, below Orange Creek Weir and above and below the Theodore Weir, approximately 128 km downstream of the Glebe Weir (Limpus *et al*., 2007). Known sites in the Fitzroy Basin that are inhabited by this species are displayed in Figure 13-8(a). It is therefore considered likely that this species is present in the Project area (Section 13.2.3.4) and appropriate mitigation measures have been developed based on this assumption.

Current pressures on the species

Nest disturbance and predation by feral pigs, foxes and goannas is the biggest threat to *R. leukops*, along with pollution and modification of riparian vegetation. Further studies into the role of water quality, drought and climate change are required to determine their effects on the reproductive success of this species (Limpus *et al.* 2007).

The operation of impoundments can, if not managed effectively, negatively affect turtle biodiversity and reduce the turtle carrying capacity of the reach; cloacal ventilating species that have life-histories linked with well-oxygenated riffle zones are the most negatively impacted by impoundments (Limpus *et al.* 2007), since inundation of riffle-pool habitat has the potential to reduce the area of foraging and nesting habitat. However, *R. leukops* is known to occur in existing impoundments on the Fitzroy River, where only flooded pool habitats are available and banks on the edges of the water storage areas are used for nesting (Limpus *et al.* 2007; frc environmental 2008).

Recreational fishing activities may also pose a threat to freshwater turtle populations, although the impact of recreational fishing on turtles has not been quantified (Limpus *et al.* 2007).

- Squatter Pigeon

Current distribution

This species occurs from Cape York Peninsula south through central Queensland to northern inland New South Wales (NSW). The southern subspecies is found south of Proserpine and the Burdekin River (Higgins and Davies 1996; Schodde and Tideman 1997) with over 100 records in the Brigalow Belt South Bioregion. Queensland remains an important stronghold for a species that has declined markedly in many parts of its range since 1905 (DEWHA 2009b).

Ecology

Squatter Pigeon forages on the ground in pairs or small flocks on a wide range of seeds, including grasses, legumes, trees and shrubs; it also occasionally takes insects. This species loafs during the day on the ground and at night roosts on low branches. It constructs a shallow scrape lined with grass in sheltered locations on the ground, such as beneath grass tussocks, bushes or fallen logs (Higgins & Davies 1996). The movements of this pigeon are poorly understood, with some evidence that it is locally nomadic (Higgins and Davies 1996).

Populations within the area affected by the proposed action

Squatter Pigeon was recorded from several habitats in the dam study area including riparian woodlands on Spring Creek and Dawson River, a Queensland Blue Gum GAB spring wetland on Mt Rose Station and pasture near Mt Rose homestead. It is also likely to occur along the pipeline route.

Current pressures on the species

Known pressures on the Squatter Pigeon (DEWHA 2009b) include the following:

- habitat loss: destruction and fragmentation of habitat due to the clearing of woodland for cropping lands and improved pastureland, which removes foraging and breeding habitat;
- habitat degradation: degradation of remaining habitat due to over-grazing by livestock and rabbits. For example, cattle grazing combined with drought in 1902 apparently caused a population decline in the Dawson River valley; and
- grazing: reduces or eliminates vegetative cover used by the species for cover and breeding purposes, reduces the availability of perennial grasses and herbaceous plants (important dietary source), and nests are vulnerable to trampling.

Suspected pressures on the Southern Squatter Pigeon include the following:

- feral animals: predation by foxes and cats;
- fire: inappropriate fire regimes, particularly during the breeding season;
- weeds: proliferation of exotic grasses (e.g. Buffel Grass) may reduce the dietary diversity, particularly the availability of perennial grasses and herbaceous plants; and
- other factors: the species may still be vulnerable to illegal hunting in certain localities, as well as trapping for the bird trade; and mortality due to ingestion of poisoned grain (aerially broadcast strychnine baits for house mice).

Existing controls and planning regimes

Currently no management plan is place that promotes the protection of this species or its habitat.

Australian Painted Snipe

Current distribution

The species is patchily distributed throughout Australia, with most records being in the south-east. Records are erratic, the species being absent from areas in some years and common in others.

Ecology

Australian Painted Snipe is a secretive, cryptic, crepuscular species that occurs in terrestrial shallow wetlands, both ephemeral and permanent, usually freshwater but occasionally brackish. They also use inundated grasslands, saltmarsh, dams, rice crops, sewage farms and bore drains. The species feeds on vegetation, seeds, and invertebrates including crustaceans and molluscs (Marchant and Higgins, 1993). They prefer sites with dense cover fringing wetlands such as rank grasses and sedges.

Breeding occurs mainly in the Murray-Darling region, though is also recorded in other parts of Queensland, NSW and South Australia. Nests are on the ground in swamps and grassland and nesting occurs between May and February, dependent on location (Marchant and Higgins 1993).

Australian Painted Snipe may breed in response to wetland conditions rather than during a particular season. It has been recorded breeding in all months in Australia. In southern Australia most records have been from August to

February. Eggs have been recorded from mid August to March, with breeding in northern Queensland also recorded between May and October (Marchant & Higgins, 1993).

Populations within the area affected by the proposed action

The Australian Painted Snipe was not recorded during the field surveys. However this species may often be overlooked during wader and other waterbird census projects because of its cryptic behaviour and occurrence in rank vegetation (Lane & Rogers, 2000). Some populations are also seasonally nomadic following local rainfall events and therefore surveys may fail to locate this species. The Australian Painted Snipe is therefore likely to be a vagrant to the Project area, depending upon seasonal rainfall events, occurring in vegetated freshwater wetlands associated with the Dawson River floodplain in the water storage area, and river floodplains along the pipeline route.

Current pressures on the species

Australian Painted Snipe is threatened by drainage of wetlands, diversion of water from rivers, clearance of wetland vegetation, and overgrazing (Garnett and Crowley 2000).

Existing controls and planning regimes

Currently no management plan is in place that promotes the protection of this species or its habitat.

28.3.5. Migratory species

28.3.5.1. Methodology

The literature review and field surveys undertaken for terrestrial fauna also encompassed EPBC listed migratory species. The methodology is described in Section 28.3.4.1.

28.3.5.2. Results

- Desktop analysis

Twenty-nine migratory species were identified as potentially occurring within the Project area based on database results.

- Field survey

Four listed migratory species have been recorded within the Project area including, White-bellied Sea-eagle, White-throated Needletail, Cattle Egret, and Rainbow Bee-eater.

- Likelihood of occurrence

An additional four migratory species are likely to occur within the Project area based on the presence of suitable habitats and proximal records from the locality. Table 28-11 discusses the likelihood of occurrence of migratory species in the Project area.

Table 28-11 Likelihood of occurrence of migratory species in the Project area

Likelihood of occurrence	Specific Name Common Name	Habitat Preferences	Likelihood of occurrence explanatory notes
Known	*Haliaeetus leucogaster* White-bellied Sea-Eagle	This species is associated with permanent waterbodies including estuaries, larger inland waterways, dams and wetlands.	Species was positively recorded from the Dawson River within the water storage.
Known	*Hirundapus caudacutus* White-throated Needletail	White-throated Needletail is ubiquitous, potentially foraging over any habitat type.	Species was positively recorded throughout the dam study area, including the water storage.
Known	*Ardea ibis* Cattle Egret	Utilises a range of habitat types including cleared paddocks.	Species was positively recorded within the water storage. Also Wildlife Online records.
Known	*Merops ornatus* Rainbow Bee-eater	Ubiquitous, potentially foraging over any habitat type.	Species was positively recorded within the water storage. Also Wildlife Online records.
Likely	*Nettapus coromandelianus albipennis* Cotton Pygmy-goose	Deeper freshwater swamps, lagoons, dams with waterlilies and other semi emergent water plants (Pizzey and Knight, 1999).	Species recorded from Lake Murphy Conservation Area, west of the study area but on the Dawson River floodplain. Suitable habitat (farm dams, Glebe Weir) exists within the impact area. No database records in the study area.
Likely	*Myiagra cyanoleuca* Satin Flycatcher	The Satin Flycatcher is found in tall forests, preferring wetter habitats such as heavily forested gullies, riparian zones and other moist habitat types.	Wildlife Online records. Suitable habitat associated with Nathan Gorge within impact area.
Likely	*Rhipidura rufifrons* Rufous Fantail	Found in a range of habitats including rainforest, dense wet forests, swamp woodlands and mangroves.	Wildlife Online records. Suitable habitat associated with Nathan Gorge within impact area capable of supporting significant number of individuals.
Likely	*Ardea alba* Great Egret	Occurs in a variety of freshwater wetland types and intertidal mudflats.	Wildlife Online records. Suitable habitat containing essential resources exists throughout water storage.
Possible	*Gallinago hardwickii* Latham's Snipe	This species prefers soft wet ground or shallow water with tussocks and other green or dead growth to scrub or open woodland; samphire areas on saltmarshes and mangrove fringes (Pizzey and Knight, 1999). Also occurs around constructed waterbodies such as farm dams.	Floodplain wetlands of the Dawson River provide ideal habitat within water storage, however no observations or records.
Possible	*Monarcha melanopsis* Black-faced Monarch	The Black-faced Monarch is found in rainforests, eucalypt woodlands, coastal scrub and damp gullies.	No observations or records, but suitable habitat associated with Nathan Gorge within impact area, however may be known to be suboptimal.

Likelihood of occurrence	Specific Name Common Name	Habitat Preferences	Likelihood of occurrence explanatory notes
Possible	*Rostratula benghalensis* Painted Snipe	The Painted Snipe inhabits freshwater and brackish wetlands, including flooded grasslands, Melaleuca swamps and saline sedgelands.	Floodplain wetlands of the Dawson River provide ideal habitat within water storage, however no observations or records.
Possible	*Numenius minutus* Little Curlew	Prefers open plains, grasslands, sports fields, parklands, mudflats, and cleared agricultural areas (Simpson and Day 2004).	No observations or records. May use floodplain during seasonal flooding events within water storage, however habitat may be may be suboptimal.
Possible	*Hirundo rustica* Barn Swallow	Prefers disturbed open agricultural areas and open urban areas for forage and roost (Pizzey and Knight 2003).	No observations or records.
Unlikely	*Crocodylus porosus* Salt-water Crocodile	Coastal rivers, swamps, estuaries and open sea north of about Rockhampton (Wilson 2005). Species has been recorded from the Freshwater reaches of the Fitzroy River, downstream of the Project area.	No observations or records. No suitable habitat upstream of Nathan Gorge.

28.3.6. Marine species

A review of the EPBC Act Protected Matters database has been undertaken for listed marine species (threatened and migratory) likely to occur in the Fitzroy River Estuary and GBRMP downstream of the dam (Table 28-12). A discussion of their likely occurrence is presented as follows.

Table 28-12 Listed marine species potentially occurring in the Fitzroy River estuary and/or Great Barrier Reef Marine Park

Scientific Name	Common Name	EPBC Act Status	Reference	
Mammals				
Balaenoptera musculus	Blue Whale	Migratory, E	EPBC	
Balaenoptera edeni	Bryde's Whale	Migratory	EPBC	
Dugong dugong	Dugong	Migratory	EPBC	
Megaptera novaeangliae	Humpback Whale	Migratory, V	EPBC	
Orcaella brevirostris	Irrawaddy Dolphin	Migratory	EPBC	
Orcinus Orca	Killer Whale	Migratory	EPBC	
Sousa chinensis	Indo-Pacific Humpback Dolphin	Migratory	EPBC	
Xeromys myoides	Water Mouse	V	EPBC	
Reptiles				
Caretta caretta	Loggerhead Turtle		Migratory, E	EPBC
Chelonia mydas	Green Turtle	Migratory, V	EPBC	
Dermochelys coriacea	Leatherback Turtle		Migratory, E	EPBC
Eretmochelys imbricate	Hawksbill Turtle	Migratory, V	EPBC	

Lepidochelys olivacea	Olive Ridley Turtle	Migratory, E	EPBC
Natator depressus	Flatback Turtle	Migratory, V	EPBC
Crocodylus porosus	Salt-water Crocodile	Migratory	EPBC
Sharks			
Pritis zijsron	Green Sawfish	V	EPBC
Rhincodon typus	Whale Shark	Migratory, V	EPBC
Pristis microdon	Freshwater Sawfish	V	EPBC
Glyphis sp.	Northern River Shark	E	EPBC

Six species of turtle listed as either threatened and/or migratory under the EPBC Act are found in the Great Barrier Reef; Green Turtles, Hawksbill Turtles, Loggerhead Turtles, Flatback Turtles, Olive Ridley Turtles and Leatherback Turtles. These turtles are likely to occur in the coastal waters offshore of the mouth of the Fitzroy River. However, only the Flatback Turtles has been recorded from the Fitzroy River estuary. The estuary is unlikely to provide appropriate habitat for the other species (EPA, 2008b).

Marine turtle species are vulnerable to changes in their habitat, such as water quality. For example, fibropapillomatosis disease is common amongst turtles in some areas, and may be related to high industrial or agricultural runoff (Kirkwood and Hooper, 2004). The diet of marine turtles depends on the species, but includes seagrass, mangrove propagules, and benthic and pelagic invertebrates. They are therefore also vulnerable to the secondary impacts of changes in water quality to their foraging habitat (e.g. the loss of seagrass or changes in benthic invertebrate community structure); particularly for the more 'inshore species' such as green and loggerhead turtles, which maintain a small foraging home range that is heavily influenced by discharges from river systems.

Marine turtles are generally highly migratory, moving between feeding grounds and rookeries, with both males and females undertaking migrations of up to 3,000 km (Environment Australia, 2003). Regionally, there are several important rookeries, including Mon Repos, to the south of the Burnett River mouth, and the islands of the Capricorn Bunker group of the Great Barrier Reef, offshore form the Fitzroy River mouth (EPA, 2006b; 2007b). Green and Loggerhead Turtles are migratory, in terms of breeding, although they tend to maintain small home ranges, ~10 – 15 km of coastline, within their foraging grounds (C. Limpus, 2007 [Queensland Parks and Wildlife Service], pers. comm., 1 June). Turtle movements within foraging grounds are likely to be related to food availability and environmental factors such as the tide cycle as they can only feed in intertidal areas when the water depth is between 0.5 – 1 m over the seabed) (Bell, 2003).

Estuarine crocodiles listed as migratory under the EPBC Act, occur in coastal and estuarine habitats downstream of the study area.

Around 30 species of whale and dolphin have been identified from the Great Barrier Reef (GBRMPA, 2007). Dwarf Minke Whales (*Balaenoptera acutorostrata*), Humpback Whales (*Megaptera novaeangliae*), and inshore Bottlenose Dolphins (*Tursiops aduncus*) are the most commonly sighted species.

Cetaceans are highly mobile species, though not all species are considered to be migratory. For example, Indo-pacific Humpback Dolphins appear to occupy a home range in inshore waters. Population distribution appears to be directly impacted by features such as water depth and habitat type, and indirectly by the distribution of prey (fish) (e.g. Jaquet and Whitehead, 1996; Benson *et al*., 2002). Cetaceans that undertake predictable migrations include the Minke Whale

and Humpback Whale, which migrate along the east coast of Australia during the winter and spring months to reproduce. Breeding and resting grounds for Humpback Whales include Hervey Bay to the south of the Fitzroy River mouth and the Whitsundays to the north; they are not known to 'stopover' in the vicinity of the Fitzroy River mouth (Environment Australia, 2002).

The Indo-Pacific Humpback Dolphin (*Sousa chinensis*) has been observed on rare occasions in the Fitzroy River estuary. It is regarded as an inshore species because it is found in shallow waters, often near river mouths, and is rarely sighted more than 1 km off shore.

The Australian Snubfin Dolphin (*Orcaella heinsohni*), a recently described species, formally *Orcella brevirostris*, has been recorded along the Capricorn Coast (Rodney and Christensen, 2006).

Dugongs (*Dugong dugon*) are found throughout the Great Barrier Reef. Dugong abundance along the southern Great Barrier Reef is generally sparse relative to their abundance in the northern parts of the reef. This is likely to be due to the small known area of inshore seagrass and the relatively small size of individual meadows (Marsh *et al*., 2002). Although there are no reports of dugongs near the Fitzroy estuary (EPA, 2008b), Shoalwater Bay is considered to be the most important dugong habitat in the GBRWHA south of Cooktown. The Fitzroy River enters the sea about 100 km south of Shoalwater Bay (Schaffelke *et al*., 2001).

Dugongs feed almost exclusively on seagrass, and principally inhabit seagrass meadows (Lanyon and Morris, 1997; Preen, 1992; Preen *et al.*, 1995). Dugongs are very variable in their movement patterns; some are sedentary and others move hundreds of kilometres in a few days (Marsh *et al*., 1999; Sheppard *et al*., 2006), although Dugong generally are considered to inhabit a home range. The reasons behind dugong movements are poorly understood but it appears that movement may be in response to environmental variables such as temperature, water levels, salinity (Sheppard *et al*., 2006), water quality (Schaffelke *et al*., 2001) and foraging for seagrass (Marsh *et al.,* 1995; Marsh and Penrose, 2001; Sheppard *et al*., 2006). Calving is likely to occur in shallow, specialised areas that are not associated with seagrass beds, and typically occurs from September to November inclusive (Marsh, 1989).

The Water Mouse or False Water-rat (*Xeromys myoides*) is also found in the Fitzroy River estuary. The Water Mouse has only been recorded within fringing mangroves in the high intertidal zone dominated by *Ceriops tagal* or *Bruguiera* spp. (Van Dyck *et al*., 2007). They forage in mangrove forests at night during a low tide. In daylight hours, or when it cannot forage, the water mouse will retreat to its nest, located anywhere from the reed/sedge zone to the mangrove zone (Van Dyck and Janetzki, 2004).

The impacts on listed marine species have been discussed collectively with the downstream impacts on World Heritage Areas, National Heritage Places and Ramsar wetlands in Section 28.4.1.

28.4. Impacts and mitigation measures

This section describes the potential impacts on MNES and the mitigation measures which have been proposed for each impact. When effective mitigation measures are not available, the discussion has been broadened to include offset strategies.

28.4.1. World Heritage properties, National Heritage places and Wetlands of International Importance

28.4.1.1. Methodology

The assessment of the significance of impacts from the Project on these MNES follows the Significant Impact Guidelines (version 1.1) (SEWPaC, 2009). The guidelines provide a specific set of significant impact criteria for each matter of NES against which the proposed action can be assessed. In reviewing the criteria and the values to be protected it was determined that the causes of potential impact could be either direct (physical disturbance) or indirect (flow regime change, sediment delivery or water quality). How each of these impact pathways relates to the Project is discussed below. As much of the pipeline route is in the Condamine catchment, which is not a reef catchment, or is upstream of the dam, potential for impact on these MNES is negligible so the discussion focuses on the dam and water storage.

28.4.1.2. Direct disturbance

There will be no direct disturbance to habitat within or proximate to the GBRWHA or the Shoalwater and Corio Bays Ramsar Wetlands.

28.4.1.3. Flow regime change

Flow regime changes as a result of the operation of the dam will be most pronounced immediately downstream (Section 28.4.3.2) but by the time the Dawson River joins the much larger Mackenzie River to become the Fitzroy, the changes are significantly reduced and by the river mouth and WHA boundary changes are negligible (Figure 28-15 and Figure 28-16). In the figures below the "full entitlement" scenario is often largely obscured by the "with dam" scenario because they are so similar.

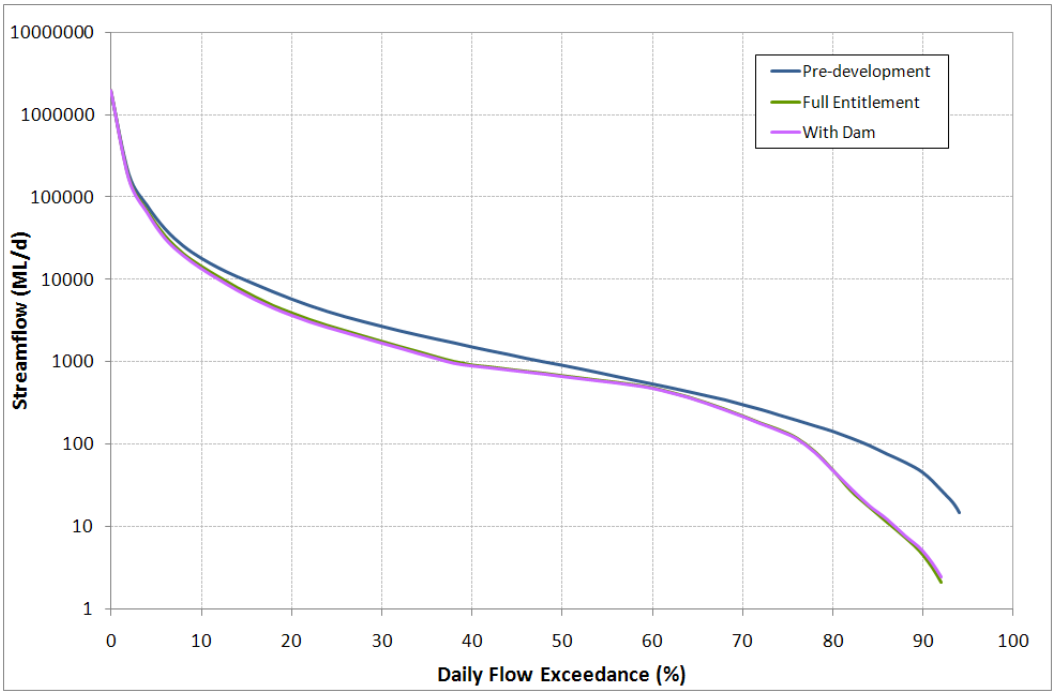


Figure 28-15 Fitzroy River at Barrage daily flow duration curve (with dam)

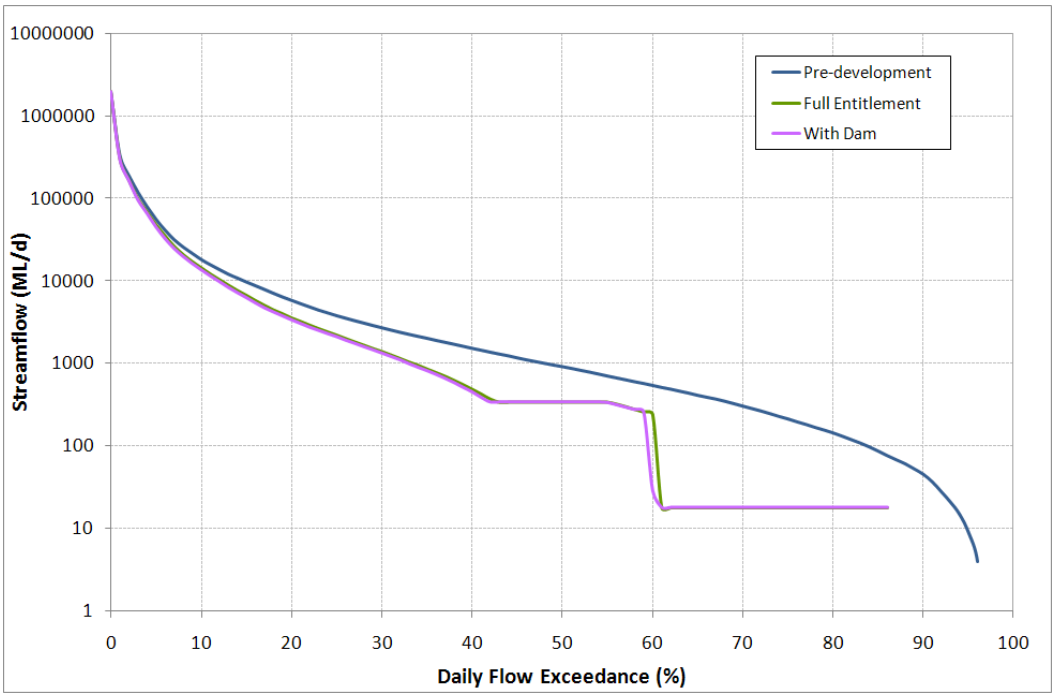


Figure 28-16 Fitzroy River at end of system daily flow duration curve (with dam)

The mean and median annual flows at the existing tidal barrage will be reduced by approximately 3% and 4% respectively. This is relative to the WRP full entitlement scenario, which (if all current entitlements were actually fully utilised) would equate to the mean being maintained at approximately 85% of pre-development levels and the median at approximately 74%.

28.4.1.4. Water quality

Construction phase

Runoff from the construction site can potentially have increased turbidity (through erosion and sediment runoff), nutrients, hydrocarbons (fuel and oil) and metal concentrations. This would be of relevance to the World Heritage Area if such pollutants could impact on the boundary of the area some 620 km downstream.

Water quality impacts during construction will be managed using a suite of standard environmental management measures as described in the EMP (Chapter 29). The aim of these procedures is to prevent discharge of any contaminants but if an accidental spillage did occur, to be able to respond rapidly and minimise the affected area. Given the distance to the WHA boundary, the likelihood of significant impact related to this hazard is considered extremely low.

Sediment and nutrient changes related to land use changes

Section 14.5.1.2 discusses in detail potential changes to sediment and nutrient loads in the river system as a result of land use change associated with the Project. The water storage area will remove 13,824 ha from grazing and other agricultural practices and effectively remove runoff of associated pollutants from that area. The dam will also act as a

trap for sediments and nutrients generated within the upstream catchment at an approximate 99% efficiency. A total of 81,000 tonnes of sediment is expected to be trapped annually.

Water harvesting opportunities for unsupplemented irrigators downstream will be reduced by approximately 10%, leading to a probable reduction in the total area irrigated of about 800 ha (depending on the primary crop type grown by the affected farmers). Depending on what use the land is subsequently put to (most likely beef cattle grazing), it is likely to lead to a reduction in runoff hence a reduction in sediment and nutrient load entering the river. Further, the planned rehabilitation of the riparian zone in the flood margin surrounding the dam and use of appropriate land as vegetation and biodiversity offsets (Section 10.4) will result in reduced sediment and nutrient runoff from the immediate dam catchment.

During operation of the dam, a multi-level offtake will allow the best quality water to be used for downstream releases, including as environmental flows at a range of fill levels. The above outcomes are likely to have a positive impact on the quality of downstream waters given the current elevated levels of these contaminants in the Fitzroy catchment. The Reef Plan and the Great Barrier Reef Protection Act (Qld) for example are strongly focussed on reducing the current loads of suspended sediment and nutrients entering reef waters.

Changes in water quality in the freshwaters downstream of the confluence with the Mackenzie River are unlikely, due to catchment influences having a greater impact on water quality than releases from the dam. As the changes in the volume of flows, seasonal patterns, and frequency of high flows to the Fitzroy estuary as a result of Nathan Dam will be minimal, changes to water quality in the estuary, including an increase in salinity due to reduced freshwater inflows, are highly unlikely. Impact to erosion and deposition processes along the coastline, river deltas and estuaries is affected by a number of processes besides those which may be influenced by the Project. The most significant of these are oceanographic processes of tides, currents, waves, storms and the movement of sediment of marine origin or of terrestrial origin built up over millennia. As the project can only influence the input of new terrestrial sediment via the Fitzroy River, its impact is limited to only that part of the erosion and deposition processes. Taking into account the likely positive impacts on sediment and nutrient loads, no significant impacts to estuarine or marine fauna including in the GBRWHA or the Shoalwater and Corio Bays Area, are predicted.

Agricultural practices in the Fitzroy Basin are improving as a result of Government and industry programs to protect the Great Barrier Reef from further impact. Reef Plan, Grains Best Management Practice incentive, Land and Water Management Plans and wide-ranging activities of the Fitzroy Basin Association are all contributing to improving receiving water quality in the Fitzroy Basin. The Project will not affect achievement of the outcomes specified in the Reef Plan and is highly likely to assist in attaining those outcomes.

28.4.1.5. Impacts on other users of the area

As no adverse water quality impacts are anticipated and hydrological changes are considered insignificant, the Proposed Action is unlikely to impact on other users within the GBRWHA or Shoalwater and Corio Bays.

28.4.1.6. Confidence in predictions

Several methodologies have been used in the assessment of the existing surface water environment and the potential impacts of the dam. Water resource modelling, using (Integrated Quantity Quality Model) IQQM, was undertaken in order to assess streamflow and water usage, as well as compliance with the Water Resource Plan (WRP) specified Environmental Flow Objectives (EFOs). While these objectives are not a Commonwealth statutory measure, they were

developed through an approved process with input from a technical advisory panel consisting of reputable scientists and using the best scientific information available. Recorded gauge data has also been used to characterise the current flow regime. Flood assessment modelling was undertaken using *URBS* and *MIKE 11*.

Water resource modelling

IQQM is the standard tool used in Queensland and NSW to simulate the impacts of water resource management on river flows. It has been subject to rigorous and widespread scientific reviews and is well regarded. As it is established to model an entire catchment within each water resource plan area it is complex and, like all models, has limitations on how natural processes are represented in the model. The accuracy of model outputs is based mainly on three types of errors, and these would apply to any model:

- Measurement errors; the accuracy of the flow measurements at any gauging station depends on the location of the gauge in the catchment relative to flow channels or floodplains and on the stability of the cross section that is measured. A gauge in a rocky gorge where all the flood flows were contained in the gorge would be very accurate whereas a gauge on a sandy river channel that regularly flooded onto a broad floodplain would be less accurate;
- Sampling error; the gauged period of record is a "sample" of the longer-term behaviour of the river. The longer the period of record, the more likely that the sample will reflect the long term behaviour. Similarly, the more gauges available to be used, the more accurate the model. Infrequent flow events such as a 1 in 100 year flood will have very few samples in the period of record so their estimation is less accurate than day to day flows or small floods; and
- Modelling error; IQQM, like any model, is a mathematical representation of real world events, in this case flow. The models are calibrated against a period of the gauged (actual) record to see how well they represent the actual record. They are adjusted until the difference between the actual and the modelled flows is minimal.

When the impact of these errors on modelling outputs are taken into account, it is generally considered that the error associated with the difference between modelled scenarios over the same period of record (as used here for the pre- and post- dam scenarios) is at best +/- 5%. This level of error will vary with the part of the flow regime in question, for example, annual flow statistics will generally show less error than individual flood events.

Preliminary operational strategy

Current water resource modelling has been developed to incorporate a preliminary operational strategy which includes the following:

- high priority water products supplied by Nathan Dam;
- environmental flows:
  - seasonal base flow;
  - first post winter flows (FPWF);
  - fishway operation; and
  - turtle way release.

The preliminary operational strategy for the dam is described in detail in Section 14.2.2.1.

It is anticipated that some details of the preliminary operational strategy will change as the Project progresses. However, the current strategy has adopted a conservative approach so that further changes are likely to have a lower impact than the current strategy. For instance, current modelling assumes that the full volume of the high priority water is used from the beginning of the dam operation. In reality high priority water will become available in stages, over a number of years.

The current operational strategy demonstrates the flexibility of the dam operations and its ability to meet a range of operational needs.

- Flood modelling

The methodology used for the flood assessment studies was in accordance with the practice recommended in Australian Rainfall and Runoff (IEAust, 2003), the industry guideline for such studies. Hydrologic and hydraulic modelling was undertaken using *URBS* and *MIKE 11*, with both models being standard modelling packages used within the industry.

Design hydrology inflows were calculated using the *URBS* model. *URBS* is a continuous/event based rainfall runoff routing model, primarily used for operational flood forecasting and design flood estimation. Flood flows and levels were estimated using *MIKE11*, a one dimension hydraulic modelling software package.

The reliability and accuracy of these models is dependent upon the accuracy and availability of reliable rainfall, streamflow and topographic data. Both models showed satisfactory calibration to recorded historical events, indicating that the modelling provides the appropriate basis for predictions in assessing impacts on matters of NES.

28.4.1.7. Assessment against significant impact criteria

An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property or the National Heritage Values of a National Heritage Place if there is a real chance or possibility that it will cause:

- one or more of the World Heritage or National Heritage values to be lost;
- one or more of the World Heritage or National Heritage values to be degraded or damaged; or
- one or more of the World Heritage or National Heritage values to be notably altered, modified, obscured or diminished.

An assessment of potential impacts on World Heritage values, National Heritage values and Ramsar wetland values is provided in Table 28-13, Table 28-14 and Table 28-15 respectively.

Table 28-13 Assessment of impacts on World Heritage values

Potential impacts	Assessment of impacts
Values associated with geology or landscape	
Damage, modify, alter or obscure important geological formations in a World Heritage property	The Project is located approximately 620 km upstream of the GBRWHA. No activity will be undertaken directly within the WHA. No indirect forms of impact are likely to impact on geological formations.
Damage, modify, alter or obscure landforms or landscape features, for example, by excavation or infilling of the land surface in a World Heritage property	The Proposed Action will not involve activities, such as excavation or infilling, within the GBRWHA.
Modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or	Hydrological changes as a result of the Proposed Action are considered insignificant.

Potential impacts	Assessment of impacts
stabilising mobile landforms, such as sand dunes, in a World Heritage property	
Divert, impound or channelise a river, wetland or other water body in a World Heritage property, and	No activity will be undertaken directly within the WHA.
Substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a World Heritage property.	Land use changes as a result of the Project will mean less cattle grazing and irrigation hence a likely reduction in associated pollutants. The water storage itself will act as a substantial sediment trap and reduce the current elevated suspended sediment and nutrient levels from the catchment. This is regarded as a positive impact in line with the Reef Plan. The construction phase risk associated with pollution events is considered very low as a result of the practices to be implemented and the distance from the Project to the WHA (approximately 620 km).
Biological and ecological values	
Reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property	As no adverse water quality or hydrological changes are predicted, no impact on plant and animal species is expected.
Fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on habitat.
Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property, and	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on populations.
Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on habitat.
Wilderness, natural beauty or rare or unique environment values	
Involve construction of buildings, roads, or other structures, vegetation clearance, or other actions with substantial, long-term or permanent impacts on relevant values, and	The Proposed Action will not involve any such activities.
Introduce noise, odours, pollutants or other intrusive elements with substantial, long-term or permanent impacts on relevant values.	Such intrusive elements are related to the construction phase and will not reach the WHA
Historic heritage values	
Permanently remove, destroy, damage or substantially alter the fabric of a World Heritage property.	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on fabric.
Extend, renovate, refurbish or substantially alter a World Heritage property in a manner which is inconsistent with relevant values.	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on historic heritage property.
Permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a World Heritage property.	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on archaeological deposits or artefacts.
Involve activities in a World Heritage property with substantial and/or long-term impacts on its values.	No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on its values.
Involve construction of buildings or other structures within, adjacent to, or within important sight lines of, a World Heritage property which are inconsistent with relevant values.	The Proposed Action does not involve construction within or near a World Heritage property.

Potential impacts	Assessment of impacts
Make notable changes to the layout, spaces, form or species composition in a garden, landscape or setting of a World Heritage property which are inconsistent with relevant values.	The Proposed Action does not involve such actions.
Other cultural heritage values including Indigenous heritage values	
Restrict or inhibit the existing use of a World Heritage property as a cultural or ceremonial site causing its values to notably diminish over time.	The Proposed Action will not restrict or inhibit the existing use of the GBRWHA as a cultural or ceremonial site. No activity will be undertaken directly within the WHA and no indirect forms of impact are likely to impact on cultural use.
Permanently diminish the cultural value of a World Heritage property for a community or group to which its values relate.	The Proposed Action will not permanently diminish the cultural value of the GBRWHA.
Alter the setting of a World Heritage property in a manner which is inconsistent with relevant values.	The Proposed Action will not alter the setting of the GBRWHA in a manner which is inconsistent with relevant values.
Remove, damage, or substantially disturb cultural artefacts, or ceremonial objects, in a World Heritage property.	The Proposed Action will not remove, damage, or substantially disturb cultural artefacts, or ceremonial objects, in the GBRWHA.
Permanently damage or obscure rock art or other cultural or ceremonial features with World Heritage values.	The Proposed Action will not impact rock art or other cultural or ceremonial features of the GBRWHA.

Table 28-14 Assessment of impacts on National Heritage values

Potential Impacts	Assessment of Impacts
Values associated with geology or landscapes	
Damage, modify, alter or obscure important geological formations in a National Heritage place.	The Project is located approximately 620 km upstream of the GBR. No activity will be undertaken directly within the GBR. No indirect forms of impact are likely to impact on geological formations.
Damage, modify, alter or obscure landforms or landscape features, for example, by clearing, excavating or infilling the land surface in a National Heritage place.	The Proposed Action will not involve any such activities.
Modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes in a National Heritage place.	Hydrological changes as a result of the Proposed Action are considered insignificant.
Divert, impound or channelise a river, wetland or other water body in a National Heritage place.	No activity will be undertaken directly within the GBR.
Substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a National Heritage place.	Land use changes as a result of the Project will see less cattle grazing and irrigation hence a likely reduction in associated pollutants. The water storage itself will act as a substantial sediment trap and reduce the current elevated suspended sediment and nutrient levels from the catchment. This is regarded as a positive impact in line with the Reef Plan. The construction phase risk associated with pollution events is considered very low as a result of the practices to be implemented and the distance from the Project to the GBR (approximately 620 km).
Biological and ecological values	
Modify or inhibit ecological processes in a National	As no adverse water quality or hydrological changes are

Potential Impacts	Assessment of Impacts
Heritage place.	predicted, no impact on ecological processes is expected.
Reduce the diversity or modify the composition of plant and animal species in a National Heritage place.	As no adverse water quality or hydrological changes are predicted, no impact on plant and animal species is expected.
Fragment or damage habitat important for the conservation of biological diversity in a National Heritage place.	No activity will be undertaken directly within the GBR and no indirect forms of impact are likely to impact on habitat.
Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a National Heritage place.	No activity will be undertaken directly within the GBR and no indirect forms of impact are likely to impact on populations.
Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a National Heritage place.	No activity will be undertaken directly within the GBR and no indirect forms of impact are likely to impact on habitat.
Involve construction of buildings, roads or other structures, vegetation clearance, or other actions with substantial and/or long-term impacts on relevant values, and	The Proposed Action will not involve any such activities.
Introduce noise, odours, pollutants or other intrusive elements with substantial and/or long-term impacts on relevant values.	No, as above.
Historic heritage values	
Permanently remove, destroy, damage or substantially alter the fabric of a National Heritage place in a manner which is inconsistent with relevant values.	No activity will be undertaken directly within the GBR and no indirect forms of impact are likely to impact on fabric.
Extend, renovate, refurbish or substantially alter a National Heritage place in a manner which is inconsistent with relevant values.	No activity will be undertaken directly within the GBR and no indirect forms of impact are likely to impact on values.
Permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a National Heritage place.	No activity will be undertaken directly within the GBR.
Involve activities in a National Heritage place with substantial and/or long-term impacts on its values.	No, as above.
Involve the construction of buildings or other structures within, adjacent to, or within important sight lines of, a National Heritage place which are inconsistent with relevant values.	No, as above.
Make notable changes to the layout, spaces, form or species composition of a garden, landscape or setting of a National Heritage place in a manner which is inconsistent with relevant values.	No, as above.
Other cultural heritage values	
Restrict or inhibit the continuing use of a National Heritage place as a cultural or ceremonial site causing its values to notably diminish over time.	No activity will be undertaken directly within the GBR.
Permanently diminish the cultural value of a National Heritage place for a community or group to which its National Heritage values relate.	No, as above.
Destroy or damage cultural or ceremonial, artefacts, features, or objects in a National Heritage place.	No, as above.
Notably diminish the value of a National Heritage place in demonstrating creative or technical achievement.	No, as above.
Indigenous heritage values	

Potential Impacts	Assessment of Impacts
Restrict or inhibit the continuing use of a National Heritage place as a cultural or ceremonial site causing its values to notably diminish over time.	The Proposed Action will not involve any such activities.
Permanently diminish the cultural value of a National Heritage place for an Indigenous group to which its National Heritage values relate.	The Proposed Action will not involve any such activities.
Alter the setting of a National Heritage place in a manner which is inconsistent with relevant values.	The Proposed Action will not involve any such activities.
Remove, destroy, damage or substantially disturb archaeological deposits or cultural artefacts in a National Heritage place.	The Proposed Action will not involve any such activities.
Destroy, damage or permanently obscure rock art or other cultural or ceremonial, artefacts, features, or objects in a National Heritage place.	The Proposed Action will not involve any such activities. .
Notably diminish the value of a National Heritage place in demonstrating creative or technical achievement.	The Proposed Action will not involve any such activities.
Permanently remove, destroy, damage or substantially alter Indigenous built structures in a National Heritage place.	The Proposed Action will not involve any such activities.
Involve activities in a National Heritage place with substantial and/or long-term impacts on the values of the place.	The Proposed Action will not involve any such activities.

Table 28-15 Assessment of impacts on Ramsar wetland values

Potential Impacts	Assessment of Impacts
Areas of the wetland being destroyed or substantially modified.	The Project is located over 620 km upstream of the Shoalwater and Corio Bays Area. No activity will be undertaken directly within the Ramsar wetland. As no adverse water quality or hydrological changes are predicted, no indirect forms of impact are likely on the wetland, and associated estuarine and marine species.
A substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland.	No, as above.
The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected.	No, as above.
A substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	No, as above.
An invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.	No, as above.

28.4.1.8. Summary of mitigation measures relevant to values

Table 28-16 provides a summary of the mitigation measures relevant to the GBRWHA, National Heritage Places and wetlands of international importance. The mitigation measures are currently included within the Project design and the Draft EMP. As the risk to these MNES was considered very low, no additional mitigation measures are proposed.

Table 28-16 Summary of mitigation measures relevant to World Heritage values, National Heritage places and Wetlands of International Importance

Potential Impact	Proposed Mitigation
Hydrological change	▪ Avoid wet season construction as far as is practicable. ▪ Downstream flows in the Dawson River will be maintained throughout the construction process. A diversion channel will be constructed to divert water around the works, with a maximum capacity of 500 m^3/s. ▪ A Flood Management Plan will be developed, including a dam safety emergency plan. ▪ Outlet mechanisms that provide flexible options for environmental flow releases. ▪ An operational strategy will be developed which will maintain key environmental flows. This will include low flows, fishway releases and a first post winter flow event release. WRP EFOs will be maintained. ▪ Develop a Critical Water Supply Strategy to manage and prioritise water supply during drought periods.
Water quality change	▪ Implementation of sediment and erosion control plan during construction. ▪ Appropriate construction methods to reduce impacts, e.g. use of sediment booms/curtains. ▪ Prohibit stockpiling adjacent to watercourses. ▪ Avoid wet season construction as far as is practicable. ▪ Monitoring of water quality downstream of construction. ▪ Substantial removal of organic matter prior to filling (vegetation clearing strategy). ▪ Monitoring water quality during filling phase. ▪ Develop a first release strategy to minimise impacts. ▪ Withholding releases if water quality is poor. ▪ Use multi-level offtake to source most appropriate water for release. ▪ Vegetation buffers, managed access for both stock and recreation purposes. ▪ Geomorphic assessment of upstream and downstream sites to ensure maintenance of hydraulic habitat and bank stability in other parts of the river system. ▪ Land use within the water storage area and construction footprint is predominantly beef cattle grazing, with some irrigated and dryland agriculture. This land will be taken out of agricultural production by the footprint of the Project. Additional surrounding land will partly be managed for environmental purposes (i.e. environmental offsets) which will greatly reduce sediment and nutrient runoff from the adjacent catchment.

28.4.2. Threatened species and ecological communities

28.4.2.1. Methodology

The potential impacts on listed threatened species and ecological communities have also been assessed against the relevant Significant Impact Guidelines Measures have been proposed to minimise or avoid those impacts on ecological values in the first instance and mitigate in the second instance. Where impacts on threatened species cannot be completely mitigated, they will be compensated by the offsets package.

When assessing impacts on a threatened species under the EPBC Act, it is necessary to consider whether the population within the Project area comprises an "important population" within the meaning of the EPBC Act. An "important population" is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

1) key source populations either for breeding or dispersal;

2) populations that are necessary for maintaining genetic diversity; and/or

3) populations that are near the limit of the species range.

28.4.2.2. Assessment against significant impact criteria

- Brigalow Ecological Community

The Brigalow EC occurs within the dam impact area (Figure 28-7), pipeline corridor and associated infrastructure. The impacts of construction and operation of the dam and pipeline on the Brigalow EC is summarised in Table 28-17. The impacts in regards to the EPBC Act Significant Impact Guidelines are assessed in Table 28-18. The impact of clearing and inundation on the Brigalow EC will be minimised by the clearing strategy and offset by the environmental offsets strategy (Section 10.4).

Table 28-17 Brigalow EC impacted by the Project

Project Element	Area of Brigalow (ha)	Impacts	Mitigation
Water storage area	127.9 ha of Remnant Brigalow (REs 11.3.1, 11.9.1, 11.9.5 & 11.9.5a) 72.7 ha of Regrowth Brigalow*	Unavoidable loss and fragmentation of Brigalow EC by clearing and inundation within the FSL.	Managed by vegetation clearing strategy. Revegetation of the northern margin of the water storage with endemic species including Brigalow. Residual impacts will be offset under offset strategy.
Pipeline	1.7 ha of Remnant Brigalow (REs 11.3.1, 11.9.5, 11.9.5a, 11.9.6)	Potential loss and fragmentation of Brigalow EC by clearing within the 30 m pipeline easement.	Avoid if possible by realignment, minimise easement width in these areas and rehabilitate post construction. If unavoidable obtain offset under offset strategy.

Project Element	Area of Brigalow (ha)	Impacts	Mitigation
Associated Infrastructure	10.6 ha of Remnant Brigalow (REs 11.9.5, 11.9.5a)	Potential loss and fragmentation of Brigalow EC by clearing within the road upgrades.	Avoid if possible by realignment, minimise easement width in these areas and rehabilitate post construction. If unavoidable obtain offset under offset strategy.
TOTAL	**215 ha**		

* The Brigalow EC is defined as remnant or regrowth more than 15 years old.

Table 28-18 EPBC Act impact assessment on the Brigalow EC

Criteria	Significance of Impacts	Mitigation and Offset
The action is likely to have a significant impact on the endangered Brigalow (*Acacia harpophylla* dominant and co-dominant) if it is likely to:		
Reduce the extent of an ecological community	The Project will reduce the extent of the Brigalow EC by up to 140.2 ha of remnant Brigalow and 72.7 ha of regrowth Brigalow. This represents 0.001% of Brigalow within the Brigalow Belt Bioregion.	The loss of Brigalow for the dam is unavoidable. Revegetation of the northern margin of the water storage with endemic species including Brigalow will occur. The impact on Brigalow along the pipeline corridor will be reduced by seeking to avoid patches of Brigalow where possible in the final pipeline alignment, and rehabilitation of the pipeline easement post construction. Where unavoidable clearing occurs at the edge of some patches, rehabilitation of the pipeline easement post construction will minimise impacts from edge effects. The loss of Brigalow will be offset by the offsets package.
Fragment or increase fragmentation of an ecological community	The Brigalow EC is currently fragmented throughout the dam study area and pipeline corridor from past clearing practices (Figure 10-4 and Appendix 10-B). The dam impact area will not fragment Brigalow occurring within the dam study area. The pipeline may fragment Brigalow patches along the pipeline route, should patches be unable to be avoided.	Avoidance as above to minimise fragmentation.
Adversely affect habitat critical to the survival of an ecological community	Critical habitat for the Brigalow EC has not been defined in the recovery plan. Brigalow within the Dawson Brigalow Belt South bioregion has been ranked as the fourth priority region out of 20 for implementation of recovery actions (Butler, 2007). The loss of 0.001% of remnant Brigalow within the Brigalow Belt bioregion is unlikely to affect habitat critical to its survival.	Avoidance, rehabilitation and offsets as above.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for the community's survival	Inundation to FSL is likely to increase groundwater levels around the water storage The Brigalow ECs occurring around the FSL are associated with land zone 3 (alluvium) and are therefore resilient and adapted to temporary flooding, and unlikely to be impacted.	Avoidance, rehabilitation and offsets as above.

Criteria	Significance of Impacts	Mitigation and Offset
	Impacts along the pipeline will not affect abiotic factors so that regeneration of Brigalow will occur within the pipeline easement. Brigalow roots will not be removed during easement clearing so that suckers can regenerate post-construction.	
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species	Brigalow is the dominant or co-dominant species in the Brigalow EC. With the exception of the direct loss of Brigalow ECs from the dam impact area and pipeline corridor, no change is expected to Brigalow ECs outside the impact area.	Avoidance, rehabilitation and offsets as above.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -- assisting invasive species, that are harmful to the listed ecological community, to become established, or -- causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community	Brigalow ECs currently have several invasive species present (e.g. buffel grass (*Cenchrus ciliaris*), harrisia cactus (*Harrisia martinii*), and velvety tree pear (*Opuntia tomentosa*)). There is potential for the spread of weed species as a result of construction and operation activities (i.e. pipeline maintenance). The Project will not introduce any fertilisers, herbicides or chemicals into the Brigalow EC. The change in land use within the water storage area (i.e. agriculture to water storage) will actually reduce the load of fertilisers and herbicides in the catchment.	A weed management plan will be implemented for construction and operation of the Project.
Interfere with the recovery of an ecological community	Recovery actions for the Brigalow EC are provided in the Recovery Plan and summarised in **Section 28.3.4**. The Project will clear and fragment the Brigalow EC, but will support recovery through increased representation in the reserve estate from offsets. The Project also supports on-ground management actions, such as the control of pests and weeds and restoration of degraded remnants, in particular around the northern margin of the water storage through the rehabilitation strategy. The conservation and management of the Brigalow EC will be promoted through on-site education of staff and contractors in particular.	Avoidance, rehabilitation and offsets as above for the pipeline. Weed and pest management

Natural grasslands

The Natural grasslands EC is located within the roadside of the Warrego Highway at Macalister, as shown in Appendix 10A-48. The pipeline route runs adjacent to the roadside in cleared private property and has been aligned to avoid most of the EC (RE 11.3.21). However, 0.07 ha of the Natural grasslands is impacted, based on the maximum 30 m wide construction easement. In reality the impact can be minimised by reducing the easement width to 15 m. The area to be avoided will be clearly marked so no construction vehicles enter.

Semi-evergreen vine thickets (SEVT)

SEVT is located as a fragmented patch on private property adjacent to the roadside of Nathan Road north of the proposed dam wall. No SEVT is located within the 30 m wide impact corridor. Along this section construction will be restricted to the roadside to avoid impacts on SEVT.

GAB discharge spring wetlands

A formal assessment using the Significant Impact Guidelines and the Recovery Plan is not undertaken as it would be inappropriate given SunWaters assessment that springs in the region are not included within the definition of the threatened ecological community. However, those documents are used as a guide to the features or types of impact that might be important for springs generally.

There are 83 mapped springs within the immediate vicinity of the Water Storage and 28 of these within 2 spring complexes (Boggomoss and Dawson River) will be flooded at FSL (Table 28-19 and Figure 28-17). This represents 10.5% of springs in the Springsure group and 1.3% and active springs nationally.

Based on the outputs of the groundwater modelling (Chapter 15), 59 springs outside the FSL will be subject to increased groundwater pressure in the Precipice and Hutton sandstones resulting in increased groundwater flow rates by 94% for springs fed from the Precipice sandstone (20) and >100% for springs fed from the Hutton sandstone. This is likely to cause an increase in the size of wetland areas and it is highly likely that new springs will be created outside the FSL. This is not listed as a threat in the Recovery Plan (Fensham *et al*., 2010) though enhancing flows and increasing weltand area is a plan objective. Whether this increase will match the area lost via inundation cannot be estimated with certainty.

Table 28-19 GAB springs impacted by the Project

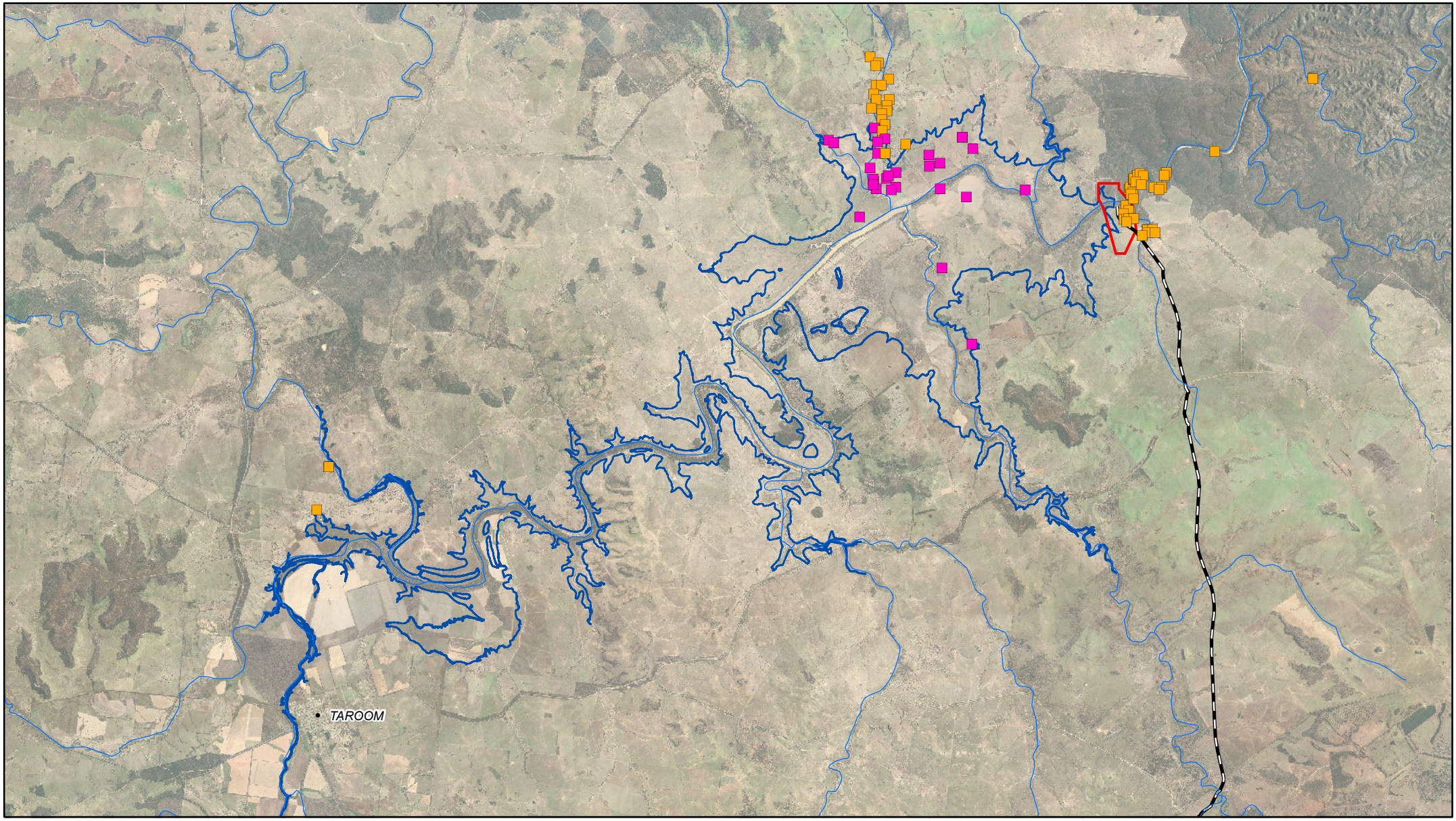
Impact Area	Spring ID	RE	Total
Water Storage	2, 3, 4, 11, 12 13, 14, 25, 29, 30, 31, 32, 33, 37, 42, 43, 44, 53, 54, 59, 61, 63	11.3.22	28
	B1, B2, B3, B4, B5, B6	Non Remnant	
Surrounding FSL	B7, B8, B9, B10, B11, B12, B13, B14, B15, B16, B17	11.3.4	55
	1,5, 6, 7, 8,9, 10, 15, 16, 17, 18, 19, 20, 21, 22, 23,24, 26, 27, 28, 34, 35, 36, 38, 39, 40, 41, 45, 46, 47, 48, 49, 50, 51, 52, 55, 56, 57, 58, 60, 62, 67, 68, 69	11.3.22	
Total			83

The impacted springs variously support vegetation communities ranging from degraded non-remnant to remnant in good condition. The impacted springs support one species, an undescribed plant *Plantago* sp. which is endemic to springs and known from the Springsure, Springvale and Eulo supergroups, however the exact location of records is currently unknown. There are also two EPBC listed threatened species that are known (Boggomoss Snail) or likely (Hairy joint grass) to occur on or near impacted springs. Impacts on these species are addressed below in accordance with the Significant Impact Guidelines.

Impacts during the construction phase will be minimised through watering of springs impacted by drawdown should they show signs of drying. Impacts to spring wetlands will require offsets in accordance with the Queensland Policy for Vegetation Management Offsets. As a result, SunWater will:

1. protect, manage and restore springs outside FSL, including those classified as category 1 and 2 GAB springs
2. protect and monitor springs created as a result of the storage
3. undertake active management of the offset spring wetlands via fire, pest and weed management and stock control.

As a result many of the actions proposed in the Recovery Plan for the threatened community will be undertaken. Threat 7 in the Recovery Plan relates to water storage impoundments. It regards Nathan Dam as already approved and goes on to identify its impacts as they relate to springs and threatened species. The Threats summary table includes a column "Future actions to reduce threats" and with respect to the threat of impoundments notes (underline added) "Ensure that future impoundment projects do not impact on GAB discharge springs". As Nathan Dam was clearly seen as current and its impacts were specifically identified, it is not a "future impoundment" and its construction would not be seen as contradicting the plan, were it to apply to these springs.



LEGEND

- Town
- Proposed Pipeline
- Watercourse
- Full Supply Level (183.5m AHD)
- Dam Construction Footprint

GAB Spring Sites

- Inside FSL
- Outside FSL

Projection: GDA94 Zone 56

Figure 28-17

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

GAB spring wetlands inundated at FSL

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- Hairy-joint Grass

The impacts in regards to the EPBC Act Significant Impact Guidelines are assessed in Table 28-20.

Table 28-20 EPBC Act assessment of significance on Hairy-joint Grass

Criteria	Significance of Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of an important population of a species?	As this species has not been identified within the Project impact area, despite targeted searches, an important population is unlikely to be present. The sizes of the populations in the surrounding GAB spring wetlands are unknown. Expansion of the wetland areas may provide more suitable habitat but may also result in changes to the composition of species, thus indirectly impacting on Hairy-joint Grass. The net result of these changes is unlikely to be significant.	Habitat for Hairy-joint Grass will be indirectly improved by measures related to the protection, management and restoration of GAB spring wetlands in the surrounding area, by reducing threats such as overgrazing and competition from pastures and weeds (TSSC, 2008ig). The GAB spring wetlands outside FSL will be monitored to observe any changes in species composition as a result of increased flows.
Reduce the area of occupancy of an important population?	No, an important population of Hairy-joint Grass is unlikely to be present.	None required
Fragment an existing important population into two or more populations?	No, an important population of Hairy-joint Grass is unlikely to be present.	None required
Adversely affect habitat critical to the survival of a species?	No habitat critical to the survival of the species has been identified within the area of impact or nearby.	None required
Disrupt the breeding cycle of an important population?	No, an important population of Hairy-joint Grass is unlikely to be present in the Project area.	None required
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	As this species was not identified at the dam impact area, despite targeted searches, loss of habitat is unlikely to lead to its decline. Expansion of the wetland areas may impact on habitat of Hairy-joint Grass at springs 1, 24 and 27.	None required
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Increased flows at the GAB springs (including springs 1, 24 and 27) located outside FSL is likely to assist the establishment of water tolerant species (both native and exotic) around the wetland areas. This may result in the establishment of exotic species in potential habitat for Hairy-joint Grass.	Weed management will be implemented during construction and operation to reduce threats associated with exotic species.
Introduce disease that may cause the species to decline?	Disease is not listed as a threat to Hairy-joint Grass and the Project will not introduce any plant diseases into the Project area.	None required

Criteria	Significance of Impacts	Mitigation and Offsets
Interfere substantially with the recovery of the species?	The Project will assist with regional and local recovery priority actions in the approved conservation advice for this species (TSSC, 2008ig) by monitoring known populations (i.e. at surrounding GAB spring wetlands) and managing conflicting land uses at those springs.	Habitat for hairy joint grass will be improved by the protection, management and restoration of GAB spring wetlands in the surrounding area. This may improve the recovery of this species in the region.

Curly-bark Wattle

The impacts in regards to the EPBC Act Significant Impact Guidelines are assessed in Table 28-21.

Table 28-21 EPBC Act Assessment of Significance on Curly-bark Wattle and Chinchilla Wattle

Criteria	Significance of Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of an important population of a species?	No individuals were recorded during the field survey so it is unlikely that an important population occurs within the pipeline easement.	A pre-construction survey will be undertaken by a qualified botanist along the pipeline route to search for this species. Should a population be identified, the final pipeline design will seek to avoid the population where possible. If unavoidable, a translocation and/or seed collection plan will be implemented to reduce the impact. Rehabilitation of the pipeline construction easement will be undertaken to reinstate potential habitat for this species and connectivity.
Reduce the area of occupancy of an important population?	The pipeline will not reduce the occupancy of any known populations of Curly-bark Wattle.	As above
Fragment an existing important population into two or more populations?	The pipeline will not fragment any known populations of Curly-bark Wattle.	As above
Adversely affect habitat critical to the survival of a species?	The pipeline will impact on potential habitat for Curly-bark Wattle, but is unlikely to impact on habitat critical to its survival.	As above
Disrupt the breeding cycle of an important population?	The pipeline will not disrupt the breeding cycle of any known populations of Curly-bark Wattle.	As above
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	The pipeline will impact on potential habitat for Curly-bark, but not to the extent that the species is likely to decline.	As above
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	There is potential for the spread and introduction of weeds along the pipeline route during construction and maintenance which may compete with potential habitat for Curly-bark Wattle along the route.	Weed management will be implemented during construction and operation of the pipeline, and will include wash down procedures for vehicles and plant and identification of weed species within construction areas prior to works commencing.
Introduce disease that may cause	The Project will not introduce disease	None

Criteria	Significance of Impacts	Mitigation and Offsets
the species to decline?	that may cause the species to decline.	
Interfere substantially with the recovery of the species?	The pipeline will not interfere with the recovery of this species or its habitat.	None

- Boggomoss Snail

The impacts in regards to the EPBC Act Significant Impact Guidelines are assessed in Table 28-22.

Impacts to the species primarily relate to inundation of known habitat at Mt Rose and the potential for downstream riparian populations to be affected by flow regime change once the dam is operational.

The water storage will inundate 0.75 ha of known habitat for the Boggomoss Snail at Mt Rose Station, resulting in the loss of one sub-population (estimated at 350 individuals). Although this represents a small reduction in population size (1.2%) and a small loss of known habitat (1.9%), the loss is of importance as it is the only remaining population that occurs in boggomoss habitat. A translocation plan will be implemented to collect and relocate as many snails as possible from the Mt Rose site to suitable sites outside the impact area. With the implementation of the translocation plan, it is considered that the size and genetic diversity of the Mt Rose subpopulation will be maintained. Existing threats to the Boggomoss Snail will be managed at these translocation sites, including weed and pest control, fire management and management of stocking rates. The translocation plan, including examples of successful relocations of native land snails, is provided in Appendix 11-E. Snails will be translocated to at least three separate sites to maximise the chances of success and spread the risk of threatening processes (i.e. fire, flooding) from destroying all relocation sites. In addition, offsets will be established for the loss of GAB spring wetlands (which provide a form of Boggomoss Snail habitat) which will likely involve restoration of degraded springs in the region.

Adoption of low flow release strategies will increase low flows relative to current levels and move towards the natural situation. This will maintain water levels, which in turn is expected to maintain riparian vegetation.

With respect to the Boggomoss snail, an assessment of potential changes to riparian flows was undertaken to determine potential impacts to the snail and it's habitat. This assessment identified that the frequency of flows that could directly physically impact on the snail or strip the riparian zone of mulch will be reduced by the Project. The seasonality of these riparian flows is predicted to be maintained. However, riparian flows are too infrequent to be the primary source of water and it is likely that riparian vegetation is reliant on a combination of water sources including groundwater and rainfall, upon which the Project will have no negative impact. It is therefore considered that the changes to downstream flows within the Isla Delusion and Southend reach of the Dawson River will provide some protection from the damaging effects of floods and is unlikely to significantly impact upon the riparian habitat. A detailed assessment of potential effects of flow regime change is presented in section 28.5.

Table 28-22 EPBC Act Impact Assessment on the Boggomoss Snail

Criteria	Significance of Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of a population of a species?	The Project will result in the flooding of one sub-population of the Boggomoss Snail at boggmosses at Mt Rose Station. In an unmitigated scenario this would result in the direct loss of an estimated 350 individuals. Based on the survey methodologies applied, combining the population estimates by BAAM and SKM, this would reduce the estimated population size by 1.2%. With the implementation of the translocation plan, it is considered that the size and genetic diversity of the Mt Rose subpopulation will be maintained. Establishment of additional separate viable sub-populations is an appropriate conservation action for this critically endangered species. The riparian populations are under threat from two natural events; floods which scour the snail's microhabitat and perhaps even drown the snails, and drying of the habitat during drought. The operational flow regime will increase low flows relative to current levels, but will decrease the number of bankfull and overbank events, resulting in a longer period between flooding events. This reduction is not anticipated to lead to any substantive change in the riparian habitat. Reduction in overbank events may also be beneficial in reducing the threat of flooding to Boggomoss Snails.	A translocation plan will be implemented to relocate the Mt Rose sub-population into suitable habitat identified outside the water storage. The translocation plan is provided in **Appendix 11.E**. This has been prepared by Dr John Stanisic in consultation with SEWPaC. Areas of known habitat downstream will be included in the offset strategy and actions will be taken in these areas to reduce threats to the species. Long-term monitoring of riparian populations will be undertaken. Should decreases in habitat health be observed then remedial measures will be developed, possibly including alterations to the operational flow regime. As part of the offset strategy, SunWater intends protecting areas of downstream riparian habitat that the snail is known to inhabit. This habitat will be improved through weed and pest management and through stock management where that is an issue.
Reduce the area of occupancy of the species?	In total the known habitat for the Boggomoss Snail is 38.81 ha across all populations. The Project will result in the flooding of 0.75 ha or 1.93% of known habitat in the region. While small, this is considered a significant impact, as it is the only known boggomoss habitat where the species occurs which is not at risk of drying out. However, it was considered to be at high risk of destruction from fire (BAAM, 2009). Successful implementation of the translocation plan, including introduction of the snail into three currently unoccupied, separate habitats, will lead to the establishment of separate viable populations and reduce the impact to negligible levels. Removal of the Mt Rose sub-population will reduce the overall range of the species as this is the most upstream known site. Favoured locations for translocation of the sub-population are in the same area so will directly address this issue.	A translocation plan will be implemented for the Boggomoss Snail (**Appendix 11.E**).

Criteria	Significance of Impacts	Mitigation and Offsets
Fragment an existing population into two or more populations?	The distribution of the snail is discontinuous and the Project will not cause further fragmentation of the populations of the Dawson River subpopulation. Although the Project will fragment the east-west riparian corridor along the Dawson River this will not impact on the Boggomoss Snail as the riparian populations are located downstream of the dam. It is likely that the Boggomoss Snail recolonises riparian habitats as a result of flooding events and this provides genetic exchange between riparian populations. The operational flow regime (**Section 11.2.1.1**) will continue to allow both bankfull and overbank flooding events to occur. Although there will be a decrease in events, this is not expected to impact genetic exchange between the riparian populations.	Operational flow regime.
Adversely affect habitat critical to the survival of a species?	The Boggomoss Snail is not exclusively associated with boggomosses and inhabits a range of moist habitats, with recent surveys finding the snail in riverine riparian zones and nearby ephemeral wetland and on boggomosses. These habitats are considered to be refugial remnants of the historical core habitat of this species. The riparian habitats are under threat from flooding and drying out. Therefore the loss of the only boggomoss habitat is significant because of its importance for long-term population viability. The reduction in flooding events is unlikely to lead to a substantive change in the riparian habitat.	A translocation plan will be implemented for the Mt. Rose subpopulation (**Appendix 11.E**). Long-term monitoring of the riparian populations. Project offset strategy regarding downstream riparian zones.
Disrupt the breeding cycle of a population?	The breeding cycle of the Boggomoss Snail is unknown, but no change is expected in the riparian populations. When the snails from Mt Rose are translocated, their breeding cycle may be interrupted as recognised in the translocation plan. With respect to the total population, such an impact is not considered significant.	The translocated snails will be monitored to record breeding and recruitment.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	As noted above, the habitat which will be lost at Mt. Rose Station represents approximately 1.93% of the available habitat. The remaining riparian habitat will be essentially unaffected by the Project.	Implementation of the translocation plan. Project offset strategy including rehabilitation of areas of downstream riparian zones.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?	The Project will not introduce feral animals to the Project area though feral pigs may favour the edges of the water storage as they do current riparian zones. No change would be expected with respect to the riparian populations. Without mitigation, the risk of increased invasion by harmful species of the snail's habitat is considered very low.	A Pest Management Plan will be prepared to manage the occurrence of declared pests within the works area, flood margin, rehabilitation areas and areas allocated to offsets. At the relocation sites measures will be implemented to manage rodents. With mitigation, the risk of increased invasion by harmful species of the snail's habitat is considered negligible.
Introduce disease that may cause the species to decline?	The Project will not introduce any diseases.	No mitigation necessary.

Criteria	Significance of Impacts	Mitigation and Offsets
Interfere with the recovery of the species?	The Recovery Plan needs to be renewed every 5 years. Given the recently acquired information on the distribution of the Boggomoss Snail, it is recommended that the Recovery Plan be renewed. This is necessary because the existing plan focussed on management of the then known two sites whereas the snail has now been found at 17 sites. The plan was adopted in July 2008 and recommended an interim review after 3 years, i.e. July 2011 so the timing is opportune. As a commitment for this project, SunWater will fund renewal of the plan. The recovery actions for the Boggomoss Snail in the current plan include assessing the weed problem and controlling if necessary; developing and implementing a fire risk management plan; fencing the habitat critical to the survival of the snail to exclude cattle; protecting the habitat of the snail through a voluntary conservation agreement with the landowners, searching for additional populations of the species; determining the impact of other threatening processes; monitoring known populations of the snail; researching the genetics of the snail; researching the ecology and life cycle of the snail; and increasing public and landholder awareness of the snail. For construction of a dam on the Dawson River, the recovery plan suggested translocation of snails as a viable mitigation measure. A number of recovery actions have already been achieved through the Project including searching for additional populations in the region and increasing public and landholder awareness through surveys and media attention of the Project.	Renewal of the Recovery Plan. The Project will assist in the recovery of the Boggomoss Snail by identifying and protecting translocation sites and areas to be included in the offset strategy. Translocation will also lead to establishment of separate viable populations or subpopulations (depending on the location of the translocation site). Monitoring of the snail will be undertaken at translocation sites (enclosures) and downstream riparian sites. The recovery of the species is expected to be enhanced by these actions.

Brigalow Scaly-foot

Table 28-23 provides an assessment of the impacts of the dam and pipeline on the Brigalow Scaly-foot and its habitat in regards to the EPBC Act Significant Impact Guidelines.

Table 28-23 EPBC Act Impact Assessment on Brigalow Scaly-foot

Criteria	Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of an important population of a species?	Brigalow Scaly-foot was not found within the Project area despite searches and therefore the Project area is unlikely to support an important population.	None required
Reduce the area of occupancy of an important population?	The Project area is unlikely to support an important population. The dam impact area will result in the loss of 264 ha of potential habitat for the Brigalow Scaly-foot incorporating Cypress Pine/Ironbark woodlands (REs 11.10.7, 11.10.7a and 11.10.9) and Brigalow/Belah open forests (REs 11.9.1, 11.9.5, 11.9.5a and 11.9.10). There is an abundance of suitable habitat for this species occurring outside the Project area in cypress pine/ironbark woodlands at Spring Creek and Nathan Gorge, and in brigalow woodlands south of the water storage area. Therefore the loss of potential habitat is not anticipated to have a significant impact on this species.	The rehabilitation and offsets strategy will compensate the loss of potential habitat.

Criteria	Impacts	Mitigation and Offsets
Fragment an existing important population into two or more populations?	The Project area is unlikely to support an important population. The Project will result in fragmentation of the east-west riparian corridor along the Dawson River, however this is unlikely to impact on Brigalow Scaly-foot, as potential habitat includes Brigalow/Belah open forests and Cypress Pine/Ironbark woodlands which occur on the periphery of the water storage area.	None required
Adversely affect habitat critical to the survival of a species?	As Brigalow Scaly-foot was found in habitat outside the Project area on Spring Creek, and not within the Project area despite searches, the Project will not impact on habitat critical to the survival of this species.	None required
Disrupt the breeding cycle of an important population?	The Project area is unlikely to support an important population. The Project will not impact on known habitat for Brigalow Scaly-foot at Spring Creek and therefore will not disrupt the breeding cycle of the population.	None required
Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline?	The Project will result in the loss of 264 ha of potential habitat for Brigalow Scaly-foot, however, habitat at Spring Creek where the species occurs will not be impacted. As the species was not found in the impact area it is unlikely that the change would lead the species to decline.	The rehabilitation and offsets strategy will compensate the loss of potential habitat.
Result in invasive species that are harmful to the species?	The Project area already supports feral cats which pose a threat to this species from predation. The Project will not introduce any feral animals to the Project area.	A Pest Management Plan will be implemented for construction and operation of the Project.
Introduce disease that may cause the species to decline?	The Project will not introduce any diseases.	None required
Interfere substantially with the recovery of the species?	Draft recovery objectives include identify and protect key habitat, manage threats, increase community awareness and increase knowledge of the species (Richardson, 2008). The Project will not substantially interfere with these objectives.	There is potential for the Project to assist the recovery of this species through protection and rehabilitation of habitat as part of the offsets strategy and implementation of a pest management plan for construction and operation.

Squatter Pigeon

Squatter Pigeon was recorded from several habitats in the dam study area including riparian woodlands on Spring Creek and Dawson River, Queensland Blue Gum GAB spring wetland on Mt Rose Station and pasture near Mt Rose homestead. It is also likely to occur along the pipeline route.

An assessment of the population of Squatter Pigeon within the Project area is provided as follows:

- Key source populations either for breeding or dispersal – the Species Profile and Threats (SPRAT) database (DEWHA 2009b) does not list any populations of Squatter Pigeon as important populations;
- Populations that are necessary for maintaining genetic diversity – the SPRAT database considers the Squatter Pigeon (southern) exists as a single, continuous inter-breeding population; and

- Populations that are near the limit of the species range – the Project area lies within the north-eastern portion of the species' range. The northern limit is noted as the Burdekin-Lynd Divide, which is generally accepted to be near Townsville around 19°S, and approximately 400 km north of the Project area. Therefore, the population at the Project area is not near the limit of the species' range.

Based on the assessment above, the population of Squatter Pigeon at the Project area is not an important population.

Table 28-24 provides an assessment of the impacts of the dam and pipeline on the Squatter Pigeon and its habitat in regards to the EPBC Act Significant Impact Guidelines.

Table 28-24 EPBC Act Impact Assessment on the Squatter Pigeon

Criteria	Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of an important population of a species?	The Project area is not considered to support an important population of Squatter Pigeon. The area of occupancy is likely to be stable at present (Garnett & Crowley 2000). The species is highly mobile (commonly observed in open, disturbed areas) and is expected to move into existing habitat (i.e. Spring Creek Station), as well as habitat that will be protected around the water storage area. Therefore the Project would not lead to a decrease in the size of the population.	The rehabilitation and offsets strategy will compensate the loss of habitat.
Reduce the area of occupancy of an important population?	The Project area is not considered to support an important population of Squatter Pigeon. Clearing of the dam construction footprint and water storage area will result in the loss of 3398 ha of potential habitat for Squatter Pigeon including grassy woodland and riparian areas. This will reduce the area of occupancy. However, Squatter Pigeon is highly mobile and is likely to move into surrounding existing habitat (i.e. Spring Creek Station), as well as habitat that will be protected around the water storage area.	The rehabilitation and offsets strategy will compensate the loss of habitat.
Fragment an existing important population into two or more populations?	The Project will result in fragmentation of the east-west riparian corridor along the Dawson River. This is unlikely to impact on Squatter Pigeon, as they readily traverse open and disturbed areas in response to seasonal conditions and access to water, and are expected to continue to utilise habitats surrounding the water storage area.	The vegetation clearing strategy will aim to minimise the impacts of fragmentation along the Dawson River to some extent by not clearing riparian vegetation within 1.5 m vertical below FSL with the aim to restore connectivity around the water storage.
Adversely affect habitat critical to the survival of a species?	Squatter Pigeon occupies a variety of habitats; however no habitats are known to be critical to the survival of this species.	The rehabilitation and offsets strategy will compensate the loss of habitat.
Disrupt the breeding cycle of an important population?	The breeding season for this species runs from late winter to summer. The nest is a scrape on the ground beneath a grass tussock. Vegetation clearing activities for the water storage area will be most intense during winter but reduced in summer once the wet season starts. This will largely avoid the breeding season. However inundation of the water storage may coincide with the breeding season which may temporarily impact on breeding birds. However, as Squatter Pigeon is fairly common in the region, the impact is unlikely to be on an important population.	None required

Criteria	Impacts	Mitigation and Offsets
Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline?	Clearing of the dam construction footprint and water storage area will result in the loss of 3398 ha of potential habitat for Squatter Pigeon. This is unlikely to lead to a decline of this species, as Squatter Pigeon is highly mobile and occurs across all grassy woodland and grassland habitats. It is likely to move into existing and compensatory habitat surrounding the water storage area.	The rehabilitation and offsets strategy will compensate the loss of habitat.
Result in invasive species that are harmful to the species?	The Project area already supports cats, dingoes and pigs which may pose a threat to this species. The Project will not introduce any feral animals to the Project area.	A Pest Management Plan will be implemented to control exotic predators within the Project area.
Introduce disease that may cause the species to decline?	The Project will not introduce any diseases.	None required
Interfere substantially with the recovery of the species?	A formal recovery plan has not been prepared for Squatter Pigeon. Recovery actions in the approved conservation advice for this species (TSSC, 2008fp) include determining population size, controlling predators (especially cats and foxes) and protection of grassy woodlands and forests. There is potential for the Project to assist the recovery of this species through provision of offsets, and pest control.	Offsets and pest management.

Australian Painted Snipe

An assessment of the population of Australian Painted Snipe within the Project area is provided as follows:

- key source populations either for breeding or dispersal – the Species Profile and Threats (SPRAT) database (DEWHA 2009b) does not list any populations of Australian Painted Snipe as important populations;
- populations that are necessary for maintaining genetic diversity – the SPRAT database considers the Australian Painted Snipe exists as a single, continuous inter-breeding population; and
- populations that are near the limit of the species range – the Australian Painted Snipe occurs throughout the Northern Territory, Queensland, New South Wales, Victoria and parts of South Australia. The Project area therefore, does not lie near the limit of the species range.

Based on the assessment above, the likely population of Australian Painted Snipe at the Project area is not an important population.

Table 28-25 provides an assessment of the impacts of the dam and pipeline on the Australian Painted Snipe in regards to the EPBC Act Significant Impact Guidelines.

Table 28-25 EPBC Act Impact Assessment on the Australian Painted Snipe

Criteria	Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of an important population of a species?	Australian Painted Snipe was not recorded during the field surveys but is likely to occur in freshwater wetlands or on farm dams with vegetation cover in response to seasonal rainfall events. As a likely visitor to the Project area, the Project area is not considered to support an important population. The Project will not lead to decrease in the size of an important population.	None required
Reduce the area of occupancy of an important population?	As a likely visitor to the Project area, the Project will not reduce the area of occupancy of an important population. The Project will result in the loss of 23 ha of potential habitat (freshwater wetlands, RE 11.3.22) for this species within the water storage area. However, the periphery of the water storage is likely to provide suitable habitat areas (e.g. dense vegetation fringing water) for this species.	None required Rehabilitation around the water storage will provide potential habitat. Offsets for GAB spring wetlands will provide potential habitat to support this species.
Fragment an existing important population into two or more populations?	This species occurs as a single, inter-breeding population throughout its range in Australia. The birds are nomadic and mobile across the landscape. Further, freshwater wetlands are fragmented across the Project area. Therefore, the Project will not fragment an existing population.	None required
Adversely affect habitat critical to the survival of a species?	Although Australian Painted Snipe can occur across Australia, the areas of most sensitivity to the species are those wetlands where the birds frequently occur and are known to breed. There are no breeding sites within or in the vicinity of the Project area and therefore the Project will not adversely affect habitat critical to the survival of the species.	None required
Disrupt the breeding cycle of an important population?	Australian Painted Snipe is an opportunistic breeder that breeds in response to wetland conditions rather than during a particular season. It has been recorded breeding in all months in Australia. Individuals may potentially use freshwater wetlands within the Project area for foraging but this is not considered to provide important breeding habitat. The creation of the water storage area may contribute to favourable breeding sites throughout the year.	None required
Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline?	As previously discussed the Project will result in the loss of 23 ha of potential habitat for Australian Painted Snipe within the water storage area. However, there is over 20,000 ha of suitable habitat for this species within the Brigalow Belt bioregion and therefore this will not lead to its decline. The water storage may create suitable habitat for this species at the periphery of the water storage area.	Offsets for GAB spring wetlands will provide habitat to support this species.
Result in invasive species that are harmful to the species?	The Project area already supports feral cats, foxes and feral pigs which may pose a threat to this species through predation of nests, or destruction of wetland habitat. Degradation of habitat by cattle trampling and grazing of tussocks and weed invasion are also a key threat. The Project will not introduce any feral animals to the Project area.	A Pest Management Plan will be implemented to control declared pests within the Project area.
Introduce disease that may cause the species to decline?	The Project will not introduce any diseases.	None required

Criteria	Impacts	Mitigation and Offsets
Interfere substantially with the recovery of the species?	A formal recovery plan has not been prepared for Australian Painted Snipe. Recovery actions for this species include protect and manage habitat at principal breeding and wintering sites, develop guidelines for the management of suitable wetlands, initiate control programs for feral animals and prevent grazing and trampling of wetlands by cattle, rehabilitate wetlands that were formerly used for breeding, improve knowledge on species habitat preferences and movements, monitor population to determine the breeding range and develop techniques to maintain a population in captivity (Garnett & Crowley, 2000; NSW NPWS, 1999). The Project area does not support any breeding populations of Australian Painted Snipe, however, non-breeding individuals may occur on freshwater wetlands on the alluvial floodplains. The loss of this habitat is not considered to substantially interfere with the recovery effort for this species.	There is potential for the Project to assist the recovery of this species through provision of offsets for GAB spring wetlands.

Fitzroy River Turtle

To date no Fitzroy River turtles have been identified within or upstream of the Project area despite the suite of site specific survey methods employed (Appendix 13-B, C & D). The only exception being an anecdotal reference to a deceased specimen on the Glebe Weir trash track (Limpus pers. comm. 2010). There are, however, records of the Fitzroy River turtle in the Dawson River, below Orange Creek Weir and at and below Theodore Weir, approximately 128 km downstream of the Glebe Weir (Limpus *et al*., 2007).

Upon commencement of construction, aquatic habitats between and under the coffer dams and the dam construction area will be lost. From this stage the habitats will be isolated from the river and will constitute a construction site. The diversion channel will connect to the river both upstream and downstream of the coffer dams and construction of the links will disturb the banks of the watercourse. Fitzroy River turtle will be removed from the work area prior to disturbance, with specialist advice sought with regards to turtle capture and relocation strategies.

Vibration, noise and sudden changes in pressure from drilling and blasting of the diversion channel are not expected to significantly impact upon the Fitzroy River turtle as, as a mobile species they would be expected to move away from the area. Significant impacts are unlikely unless blasting occurs very close to, or in, the river though this is currently not envisaged.

The impacts of disturbance to habitat during the construction phase will be highly localised and are considered acceptable in both a local and regional context, given the expected relatively small disturbance footprint.

During operation of the dam, approximately 75.2 km of the Dawson River (including approximately 30 km currently inundated by Glebe Weir) will be inundated along with 90.8 km of other major streams. The current coarse sediment (boulders, cobbles, pebbles and gravel) will likely be smothered in fines and sands, once the water storage area and buffer is filled, though some will remain in the shallow delta areas where streams enter the storage.

Riffle-pool sequences are thought to be of particular importance to the Fitzroy River turtle, however, riffle zones throughout most of its' range are likely to be ephemeral, short lived and account for only a minor portion of the total habitat. As such, the Fitzroy River turtle should not be considered a riffle zone specialist (Section 13.1.3). Irrespective, the vast majority of habitat to be flooded following construction of Nathan Dam is existing pool habitat.

Inundation of riffle-pool habitat has the potential to reduce the area of foraging and nesting habitat for the Fitzroy River turtle. However they are known to occur in existing impoundments on the Fitzroy River and Dawson River, where only flooded pool habitats are available and banks on the edges of the inundation and buffers are used for nesting (Limpus *et al,*. 2007; frc environmental, 2008, DERM 2011). Therefore, the water storage area is likely to be used by these species, along with the others that have been recorded in the study area (Section 13.2.3.4). Ensuring structural habitat remains and is placed within the shallower margins will significantly enhance the potential utility of the storage.

Potential impacts to Fitzroy River turtle may result from the operation of the offtake structures in the form of entrapment in the offtake and outlet works. Screens covering the multi-level offtake will direct turtles towards the turtleway entrance.

While the effects of fauna overtopping weirs and spillways is poorly understood, some fish and turtles have been observed dying after overtopping weirs during large flow events (Clay 1995). Mortality is thought to be the result of impact forces and shearing against the concrete spillway. Factors affecting survival are the height of the spillway, whether it is stepped or smooth and the size of the animal. Turtles are the animals most likely to be near the spillway, and suffer mortality as a result of going over the spillway. The spillway has been designed to be smooth and thus, turtles will be unable to climb over and into the spillway.

If the dissipation device is not appropriately designed, it may result in a velocity barrier in the Dawson River for turtles, preventing upstream migration to the turtleway. Other potential impacts include entrapment of fauna in the stilling basin and subsequent damage from floods or debris and increased predation.

Impacts to turtles and other aquatic fauna will be reduced through spillway and energy dissipation devices which will be constructed such that turtles are prevented from entering the stilling basin from downstream and being injured by floodwaters and debris coming over the spillway. Any stabilisation works required on river banks downstream from the dam will aim to provide habitat as well as perform their engineering function.

With respect to turtle movement, fishways have traditionally been less successful in providing adequate passage for turtles, which move within rivers to access feeding and / or breeding habitat. Turtles prefer to walk upstream rather than use fishways and are unlikely to use the fishway in significant numbers. A turtleway has been included as a design feature of the dam and will accommodate the upstream and downstream movement of turtles past the dam wall (Chapter 2). DERM turtle experts have been consulted and this consultation will continue to ensure maximum potential benefits are identified and achieved.

It should be noted that while the fauna transfer devices on Nathan Dam will incorporate the best technology available, the numerous weirs downstream on the Dawson River, and at Glebe Weir, do not have such devices so the change in net impact on movement within the Dawson River system will be relatively minor.

An assessment of post-dam flows and geomorphology within the unimpounded reach immediately above Theodore Weir and below Orange Creek Weir indicated that changes to flows which may significantly alter the habitat structure or water quality characteristics of this reach are not expected (Chapter 14).

With populations known from within other storages within the Fitzroy Basin, it is expected that Fitzroy River turtles currently utilising the Dawson River within the proposed water storage area will inhabit the dam.

An assessment of the population of Fitzroy River Turtle within the Project area is provided as follows:

- key source populations either for breeding or dispersal – the Species Profile and Threats (SPRAT) database (DEWHA 2009b) does not list any populations of Fitzroy River turtle as important populations however Limpus (2007) has stated that "The best population today, based on identified nesting, occurs within the Fitzroy Barrage impoundment", an area which will be unaffected to any substantial degree by any aspect of the Project;
- populations that are necessary for maintaining genetic diversity – the Species Profile and Threats (SPRAT) database (DEWHA 2009b) does not list any populations of Fitzroy River turtle that are necessary for maintaining genetic diversity; and
- populations that are near the limit of the species range – the Fitzroy River turtle occurs throughout the Fitzroy Basin. Currently no Fitzroy River turtle have been identified within the Project area with the exception of an anecdotal reference to a deceased specimen on the Glebe Weir trash track (Limpus pers. comm. 2010). It is not known whether this species is near the limit of its range.

Based on the assessment above, the likely local population of Fitzroy River turtle at the Project area is not an important population.

Table 28-26 provides an assessment of the impacts of the dam and pipeline on the Fitzroy River turtle in regards to the EPBC Act Significant Impact Guidelines. With no Fitzroy River turtles recorded within the water storage area, the primary focus in determining the significance of potential impacts has been the assessment of potential changes to the flow regime and subsequent impacts on foraging habitat, particularly riffle habitat between Orange Creek Weir and the upper reaches of Theodore Weir. This regulated reach (approximately 26 km) of the Dawson River has known nesting locations and species records. The pipeline is largely within the Condamine catchment or traverses ephemeral tributaries of the Dawson River which are not likely to provide suitable habitat for the species.

Discussed in Section 28.3.4, riffles have been identified by some as significant habitat attribute for *R. Leukops*. However, under low flow events, or as riffle zones become seasonally ephemeral (i.e. dry completely), *R. leukops* retreat to deeper sections of pool habitats, or even isolated waterholes, adjacent to riffle zones (Limpus *et al.* 2007, Tucker *et al.* 2001). As riffle zones throughout most of the range of the Fitzroy River turtle, including in the Dawson River, are likely to be ephemeral, this species should not be considered to be a riffle zone specialist; rather, they exploit this habitat to forage for abundant food sources such as benthic invertebrates and algae in riffle zones during the wet season and early dry season (Limpus *et al.* 2007). As such an assessment of potential changes to low flows was undertaken. This hydrological assessment identified that the Project will not have a significant impact on these low flow conditions.

Impacts from changes in flow regimes will be most pronounced immediately downstream of the dam. The nearest streamflow gauge site to the dam is Nathan Gorge. Figure 28-18 to Figure 28-22 compare the modelled flow duration curves for the Pre-development, Full Entitlement (current permitted development level) and 'With Dam' scenarios along the Dawson and Fitzroy Rivers.

The modelled flow duration curves show that directly downstream of the dam at Nathan Gorge, and at the majority of locations in the 'With Dam' scenario, the flow regime will more closely simulate natural flows than the current Full Entitlements scenario for critical low flow periods. This is due to flows released for Low Flow, Fishway and Turtleway operation, the seasonal baseflow release and flows released to maintain downstream storage volumes.

Mitigation strategies for impacts to Fitzroy River Turtles relate to habitat change, imposition of a barrier and flow regime change and are presented below. The strategies incorporate commitments already made in the Description of Project as well as items based on previous advice from Col Limpus, a DERM turtle expert. SunWater is committed to continue consultation with DERM, SEWPaC and Fisheries Queensland in regards to mitigation measures proposed. The mitigation strategies are:

- capture and translocation of fauna within the construction footprint prior to works commencing;
- provision for aquatic fauna passage at all temporary and permanent watercourse crossings;
- provide snag habitat in shallow areas on the edge of the storage and in in-flowing tributaries by not clearing within 1.5 m vertical of FSL and through placement of snags salvaged during clearing of the impoundment area;
- use of a smooth spillway;
- design and orientate screens and filters on intakes to prevent turtles being attracted to the intakes and trapped;
- reduce mortality and injury to turtles during passage over impoundment structures during over-topping events by providing a 'soft landing' e.g. a deep stilling basin;
- reduce death and injury of turtles aggregated at or within the downstream side of outlet structures by reducing the velocity of high volume water release events and excluding turtles from outlet structures that produce high velocities;
- discourage turtles from climbing unsafe locations on impoundments by, for example, having an overhanging, smooth surface at least 1m high immediately below the structure lip;
- increase in the rate of release of water from outlet structures gradually in order to prevent physical damage to turtles*;*
- restrict the stocking of fish which prey upon turtles (particularly hatchlings) in the impoundment (This is SunWater's preferred position but stocking is controlled by DEEDI);
- reduce the incidence of death and injury to turtles from boat strike, propeller cuts and fishing activities (SunWater will provide informational signage at the boat ramps);
- maintain flows downstream that 'mimic' the natural characteristics, particularly the post winter and base flows as determined by the WRP;
- manage terrestrial and aquatic weeds in the storage area, the flood margin and riparian rehabilitation area to prevent them from blocking access to suitable nesting habitat for turtles;
- monitor the changes in nesting banks downstream from infrastructure and, where necessary, rehabilitate nesting banks that have not rejuvenated as a result of reduced flood flows (SunWater commits to find nesting banks at Theodore Weir and then to sponsor this monitoring and rehabilitation (the latter if shown to be necessary),in that area);
- manage riverine sand mining so that it does not negatively impact on turtle nesting banks (The Project does not propose sand mining in the Dawson River). SunWater will source materials from licensed providers; and
- manage the terrestrial zone around the impoundment to reduce loss of turtle eggs from predation by feral and native animals and avoid damage to nesting habitat from trampling by stock to increase nesting opportunities and the recruitment of hatchlings into the river (the Project includes management of the flood margin and riparian rehabilitation area. This includes reduced grazing and management to control weeds and feral animals).

In summary, once the above strategies are implemented it is suggested that while impacts to Fitzroy River turtle are possible they are likely to be few. With the exception of a single anecdotal record within the water storage area, no Fitzroy River turtles have been reported within the Project area. The habitat value of the storage itself will be maximised as far as practical, by the proposed mitigation strategies and the Project's riparian zone and environmental offset strategy. Downstream flow regime impacts can be effectively mitigated by adherence to the environmental flow objectives of the Water Resource Plan. SunWater suggests that the residual impacts are minor and acceptable.

SunWater commits to monitor the impacts and the effectiveness of mitigation strategies. Final design of the monitoring program will be developed in consultation with DERM and SEWPaC. Monitoring will include:

- recording the sex and number of individuals moved, and where they were moved to, during translocation from the construction area (most appropriate relocation sites will be confirmed with DERM turtle experts). Individuals will be pit tagged using DERM approved techniques;
- annual population surveys will be undertaken during the nesting season in areas upstream of the water storage area which supports suitable habitat, within the water storage and downstream as far as Theodore Weir to assess the population and the likelihood of nesting (using non-invasive ultrasound techniques). All individuals captured will be pit tagged. Results will be assessed with respect to the monitored flow regime, dam water levels, fishway and turtleway evaluations and changes over time;
- if nesting is observed within the dam catchment, the nests will be protected from predators using mesh cages (as used in the Fitzroy Barrage and Mary River) and the site will be inspected for evidence of hatching at the appropriate time;
- use of the fishway and turtleway will be monitored and reported; and
- offtakes, outlet structures and the spillway will be inspected for evidence of injury or death caused to turtles and any such observations will be reported to DERM. If evidence suggests that design of the screens, stilling basin or outlet structures can be improved to avoid or minimise such instances, feasible and practical modifications will be undertaken as a corrective action.

SunWater suggests that if the monitoring programs do not detect the species within the water storage, or do not find nesting banks in particular areas after a reasonable period, say 5 years, then SunWater's sponsorship of such monitoring should cease.

There is a general belief that traditional fish transfer devices do not adequately cater for turtles. However the most recent monitoring data from Paradise Dam on the Burnett River (QPIF 2009) shows that the upstream fishway is catering for significant numbers of some turtle species. Irrespective, the Nathan Dam proposal includes a specific turtleway. The transfer device will include pit tag readers to easily monitor turtle movement.

While it is considered very likely that effective transfer will result from the design outlined above, SunWater suggests that if monitoring shows this is not the case, effective short term transfer and genetic mixing could be achieved by simple catch and carry techniques. The technique can also be used for other turtle species. In the longer term the results from SunWater sponsored programs noted below could be incorporated into the modification of turtle transfer devices, if required. SunWater does not anticipate that such actions will be necessary but is committing to the long term success of turtle movement processes at Nathan Dam and is prepared to undertake the necessary actions to ensure that success.

SunWater will provide an environmental offset. The direct offset for this Project is suggested as protection and management of sections of river and riparian zone downstream from the dam which may support the species. This would need to be negotiated and agreed with the landowner/s. Management measures would include reduction of grazing pressure, weed control and feral animal control. It is suggested that further survey be directed in this region to identify areas of greatest utility to the species, particularly nesting areas, and that these be the target of management actions. The environmental offset strategy for the Project includes the need to find and secure suitable Order 5/6 stream watercourse vegetation (to meet State requirements) as well as habitat for the Boggomoss Snail. SunWater aims to achieve this as far as possible in the area immediately downstream of the dam. This will be of direct benefit to the Fitzroy River turtle and the aim is to co-locate these offsets. An Order 5/6 offset relates to protection of a 200 m wide strip of riparian zone either side of the river and SunWater aims to obtain as much of this offset as possible between the dam and Theodore.

The SunWater Board and shareholding ministers have also approved a commitment of $4 M from the dividend reinvestment scheme toward design, construction and monitoring of turtle transfer systems. The approved project will place emphasis on Fitzroy River turtles. It is envisaged that an existing weir which currently has no facility for passage will be fitted with alternative designs and the designs will then be modified depending on results of monitoring. It is currently envisaged that Tartrus Weir on the Mackenzie River will be targeted as it is known to represent a significant barrier and DERM turtle research team members have observed Fitzroy River Turtles congregating in the rock pools downstream. DERM turtle experts will assist with the process and Central Queensland University will be invited to participate by way of postgraduate research projects. It is expected that the Project, which has commenced, will continue over approximately 2 years. The results will be used to inform the design of turtle transfer facilities on any future dams or weirs and enable informed retrofitting to existing structures. The Project has direct links to the "Overcoming the barriers – fishways" component of the approved regional NRM body (Fitzroy Basin Association) investment plan.

SunWater is the proponent or joint proponent for three projects in the Fitzroy catchment (Connors River Dam, Nathan Dam and Lower Fitzroy Weirs) and each of these projects is likely to have residual impacts on the Fitzroy River Turtle after implementation of all mitigation strategies. Each is likely to offer direct offsets in or near its area of impact as has been done for Nathan Dam above. SunWater recognises the potential for cumulative impacts on the species. SunWater suggests that a catchment wide research and monitoring program, linked to the necessary monitoring associated with each project, should be implemented. It is only relatively recently that night time sampling techniques using spotlighting have been shown to be an effective means of finding the species. Coupled with a sparse geographic sampling effort over the years as a result of limited funding, SunWater suggests that a systematic survey using the now recognised most useful techniques, is highly likely to significantly increase the known range of the species and the estimates of population density. The recent photographic evidence of a specimen from Glebe Weir as well a new records below Orange Creek Weir increases the range by 100 river kilometres from Theodore Weir and it is very likely that the species will be found in between these locations and possibly upstream of the Glebe Weir pool, though repeated surveys (sampling has often been in difficult conditions) have failed to locate it. Similarly a review of Figure 4.2 in Limpus *et al.* (2007) for example, suggests there are no known occurrences between Cardowan and a point near where the Mackenzie River joins the Dawson River, a distance of over 250 river kilometres. This is considered highly unlikely as the species is known to exist both upstream and downstream and only two sites have historically been sampled in this long stretch of river.

SunWater proposes to commit $100,000 per annum per constructed project for a period of 5 years to this program. The design of the program would be formulated via discussion with SEWPaC, DERM and relevant researchers. It is intended to link the funding to the "Biodiversity and Vegetation" component of the existing FBA regional NRM plan and to Central Queensland University research programs in order that the SunWater seed funding can be used to leverage further funding or in-kind support, thereby substantially increasing the scope of the Project. The "Biodiversity and Vegetation" component of the regional NRM plan includes Fitzroy River Turtle as a focus species and community engagement in turtle conservation, primarily through Greening Australia and other volunteers protecting nest sites in certain downstream areas, has been very successful. For example it was suggested that approximately 90% of nests are predated if protection by volunteers is not undertaken.

SunWater suggests that the research should be directed at both ecological parameters (distribution, abundance, location of nesting areas, etc.) and at practical means to reduce the impact of existing structures. As SunWater manages a number of existing structures in the system, such knowledge will be very useful with respect to possible adjustment of the operational regimes in order to reduce incidental impacts to turtles. Limpus *et al* (2007, page 16-17) suggested that with such a catchment wide approach "it will be possible to reverse the negative impact of not only the new infrastructure developments but to also compensate for the cumulative impacts".

Table 28-26 Assessment of impacts on Fitzroy River Turtle

Potential Impacts	Significance of Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of an important population of a species	Based on the assessment above, the likely local population of Fitzroy River turtle at the Project area is not an important population. The species has not been recorded within the Project area (other than anecdotally). Similarly there is no evidence to suggest that the habitat is of particular quality or value. Nearest confirmed nesting is approximately 45 km downstream below Orange Creek Weir. There will be a small reduction in potential foraging efficiency due to the conversion of riffle habitat to (the equivalent of) deeper pool habitat within the storage area, noting very few riffles were identified during baseline surveys. Under low flow conditions, with the slight over compensation of these low flows downstream of the dam, these flows will contribute to maintaining water quality in pools downstream. It is not expected that the Project will lead to a long-term decrease in the size of the population.	As described above, SunWater has committed to a wide range of mitigation measures to reduce the impact on the Fitzroy River Turtle.
Reduce the area of occupancy of an important population	Fitzroy River turtle is known to persist in weir pools and regulated reaches, with breeding populations recorded from Fitzroy Barrage and Theodore Weir. If it is present within the water storage area it is expected to utilise the shallow edge habitats and the water storage will provide a suitable dry season / drought refuge for the species at all stages of its lifecycle. With respect to downstream populations, as no adverse water quality impacts are anticipated and hydrological changes are considered insubstantial in terms of effects on the turtle, any reaches downstream of the dam which currently support Fitzroy turtles will remain.	As above
Fragment an existing important	Based on the assessment above, the likely local population of	Design and implement a

Potential Impacts	Significance of Impacts	Mitigation and Offsets
population into two or more populations	Fitzroy River turtle at the Project area is not an important population and therefore there is no fragmentation. The dam wall is, without mitigation, a complete barrier to upstream fauna movement and an almost complete barrier to downstream movement. A turtleway (and fishway) has been included in the preliminary design to accommodate both movement directions and is intended to service the needs of turtles and other fauna. The detailed design of the turtleway and the spillway stilling basin will aim to maximise potential movement while reduce the potential for physical damage. DERM turtle experts have been consulted to ensure maximum potential benefits are identified and achieved.	turtleway into Nathan Dam that will allow the movement of turtles in both directions.
Adversely affect habitat critical to the survival of a species	As no turtles have been confirmed in the Project area, it is unlikely that it constitutes critical habitat. "The best population today, based on identified nesting, occurs within the Fitzroy Barrage impoundment" (Limpus, 2007). The Project will not significantly alter water quality, hydrology or geomorphology at this location. Breeding and recruitment has also been confirmed in a number of locations within the Fitzroy Basin but not within the Project area, despite repeated sampling (albeit at times in difficult conditions). The hydrological analysis indicates that the flow regime within the unimpounded reach above Theodore Weir will not be significantly impacted and may experience slightly elevated low flows above the full entitlements scenario. Further, the reduction in minor flood flows as a result of capture by the dam during the important post winter period is mitigated through mandatory environmental releases during this period. In conjunction with use of the multi-level offtake expected to deliver suitable water quality and flows, the Project is not likely to adversely affect critical habitat.	Ensure downstream flows compliant with WRP. Monitor nesting banks downstream from Nathan Dam (and if found) and where necessary, rehabilitate those nesting banks that have not rejuvenated as a result of reduced flood flows.

Potential Impacts	Significance of Impacts	Mitigation and Offsets
Disrupt the breeding cycle of an important population	The population of Fitzroy River turtle in the shallow and slow-flowing Fitzroy Barrage impoundment is a well-functioning population, with several nesting banks available (Limpus *et a*l 2007, frc environmental 2007). There are no nesting sites for the Fitzroy River Turtle known from the water storage area. Searches of potential nest banks during four separate baseline surveys failed to locate any evidence of nesting activity by this species but eggs of other species were found.	Maintain flows and monitor nesting banks as above
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There is no evidence to suggest that the habitat is of particular quality or value with no records of the species within the Project area (other than anecdotally). The 2007/2008 EIS baseline study found that pools were the dominant habitat type within the study area. Rather than decrease the availability of such sites, the impoundment itself is likely to become an important dry season refuge for turtles, including the Fitzroy River Turtle. In relation to the loss of microhabitat used as shelter, the edge of the impoundment has the potential to meet the habitat requirements of the species. Preservation of riparian vegetation surrounding the water storage will ensure long term inputs of coarse woody debris to the system. It is also intended that in-stream timber is retained and / or woody debris or artificial structures will be placed in the water storage area to replace lost large woody debris habitat. These measures will ensure that suitable microhabitats are available as shelter for the Fitzroy River Turtle. Further as the Project will not significantly alter water quality, hydrology, geomorphology and other habitat characteristics for the Fitzroy River Turtle the Project is not likely to lead to the decline of the species.	As above
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Invasive species in the Project area are also found generally throughout the catchment. No new invasive species are predicted to occur as a result of the Project.	No mitigation necessary.
Introduce disease that may cause the species to decline	The Project is not likely to introduce disease to the Fitzroy River turtle.	No mitigation necessary.
Interfere substantially with the recovery of the species	A formal recovery plan has not been prepared for this species. Actions committed to by the Proponent across all water resource developments in the catchment are predicted to be of substantial long term benefit to the species.	

Other Possible Species

Species considered as possible to occur in the Project area are only impacted by loss of potential habitat and in each case this is covered by the rehabilitation and offset strategies which include establishment and or protection of such potential habitat.

28.4.3. Migratory species

28.4.3.1. Introduction

Four migratory species are known from the Project area and four migratory species are considered likely occurrences based on the presence of suitable habitats.

28.4.3.2. Methodology

The likely impacts resulting from the Project construction and operation have been identified in the Terrestrial Flora, Terrestrial Fauna and Aquatic Fauna chapters of the EIS. Measures have been recommended where required to minimise or avoid those impacts on ecological values in the first instance and mitigation of impacts in the second instance. The impacts and mitigation have been summarised in the following sections.

The assessment of the significance of impacts from the water storage area and pipeline construction and operation follows the Significant Impact Guidelines (version 1.1) prepared by the DEWHA (2009).

28.4.3.3. Occurrence of important habitat in the Project area

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species. Some factors that should be considered include the species' population status, genetic distinctiveness and species specific behavioural patterns (e.g. site fidelity and dispersal rates). This assessment has reviewed this information with respect to each species in order to provide the pooled summary herein.

'Population', in relation to migratory species, means the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries including Australia (DEWHA, 2009).

In relation to the occurrence of important habitat within the Project area, the following is noted:

- the Project area does not contain habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species;
- the Project area does not support habitat known to be of critical importance to any species at particular lifecycle stages;
- none of the species recorded is considered to be at the limits of its range in the Project area; and
- none of the migratory species recorded is known to be declining in the Project area.

28.4.3.4. Impact assessment

An assessment of the level of impact of the Project on the five migratory species recorded is provided in Table 28-27.

Table 28-27 EPBC Act assessment of significance on migratory species known from the Project area

Criteria	Significance of Impacts
The action is likely to have a significant impact on a migratory species if it is likely to:	White-bellied Sea-eagle White-throated Needletail Cattle Egret Rainbow Bee-eater
1. Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat of the migratory species; or	There is no evidence to suggest that the Project area supports important habitat for any migratory species. Given their migratory habits, the ephemeral nature of important food and habitat resources and the extent of similar and comparable habitat throughout the range of these species, it is likely that the habitats on the Project area would be utilised infrequently and on a transitory basis only. **White-bellied Sea-Eagle** The Project area does not provide important habitat for this species. This species was recorded over the Dawson River during the field survey and is known to occur within other impoundments. It is expected to utilise the Project area post-inundation. **White-throated Needletail** This species is an aerial insectivore, and is almost exclusively aerial, foraging over most habitat types including cleared land. It was recorded during the field survey, however habitat for this species is abundant throughout its range and is unlikely to be impacted by the Project. It is likely that the water storage will provide suitable habitat areas for this species. **Cattle Egret** This species occurs either permanently or seasonally, across most of the higher rainfall pastoral lands of coastal and sub-coastal Australia. It can also be found in pasture amongst stock and occasionally in the shallows of wetlands. The Cattle Egret was recorded within pastures of the water storage area during the field survey. Habitat for this species is abundant throughout the range of this species, and creation of the water storage area would provide suitable wetland habitat for this species. **Rainbow Bee-eater** The Rainbow Bee-eater was recorded throughout the Project area in woodland communities. Some areas of suitable habitat would be removed by the Project, however preferred habitats are widely distributed throughout the range of the species and the Project is unlikely to significantly impact on the species.
2. Result in invasive species that are harmful to the migratory species becoming established in an area of important habitat of the migratory species; or	Based on the survey results there is little evidence to suggest that the Project area supports important habitat for these migratory species. Much of the Brigalow Belt South bioregion, including the Project area, has a history of forest clearing and habitat modification, which has benefited a number of feral and invasive flora and fauna species. The Project is unlikely to further increase the rates of species invasion that would result in harmful affects to the habitat of these migratory species.

Criteria	Significance of Impacts
3. Seriously disrupt the lifecycle (breeding, feeding migration or resting behaviour) of an ecological significant proportion of the population of a species.	There is no evidence to suggest that the Project area supports an ecological significant proportion of the population of these migratory species. **White-bellied Sea-Eagle** Breeds in large stag trees overlooking open water. The water storage area is therefore likely to provide additional breeding sites for this species. **White-throated Needletail** Aerial forager of insects over most habitat types. The water storage area is therefore likely to provide suitable foraging habitat for this species. **Cattle Egret** Widespread in pasture amongst stock. This type of habitat is abundant surrounding the water storage area and along the pipeline route. **Rainbow Bee-eater** More likely to breed in sandy habitats along the Dawson River and smaller waterways, breeding opportunities will remain outside the water storage area.

An assessment of the impacts on the four potentially occurring species has been grouped as follows; wetland and shorebirds and terrestrial species and the potential impact are assessed in Table 28-28.

Table 28-28 EPBC Act assessment of significance on migratory species likely to occur

Criteria	Assessment of Significance	
The action is likely to have a significant impact on a migratory species if it is likely to:	Migratory wetland and shorebirds: ▪ Great Egret ▪ Cotton Pygmy Goose	Terrestrial species: ▪ Satin Flycatcher ▪ Rufous Fantail
1. Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat of the migratory species; or	There is no evidence to suggest that the Project area supports important habitat for any migratory species. Given their migratory habits, the ephemeral nature of important food and habitat resources and the extent of similar and comparable habitat throughout the range of these species, it is likely that the habitats on the Project area would be utilised infrequently and on a transitory basis only. **Migratory wetland and shorebirds** These species are reliant on or never far from a permanent water source. Some of these species occur within an area in response to seasonal rainfall events whilst others may be associated with permanent water (e.g. Great Egret). The creation of the water storage area is likely to provide habitat for these species. **Terrestrial species** These species are generally reliant on moist and closed forest systems along waterways within the Project area. Some of these will be impacted by inundation, although much of the riparian vegetation below FSL will be retained until shortly before inundation. The provision of vegetation rehabilitation and offset areas will replace this habitat type within the local area.	
2. Result in invasive species that are harmful to the migratory species becoming established in an area of important habitat of the migratory species; or	Based on the survey results there is little evidence to suggest that the Project area supports important habitat for these migratory species. Much of the Brigalow Belt South bioregion, including the Project area, has a history of forest clearing and habitat modification, which has benefited a number of feral and invasive flora and fauna species. The Project is unlikely to further increase the rates of species invasion that would result in harmful affects to the habitat of these migratory species.	

Criteria	Assessment of Significance
3. Seriously disrupt the lifecycle (breeding, feeding migration or resting behaviour) of an ecological significant proportion of the population of a species.	Given that these species have not been recorded from the Project area, there is no evidence to suggest that the Project area supports an ecological significant proportion of the population of these migratory species. **Migratory wetland and shorebirds** It is likely that the creation of the water storage area will create habitat for these species. **Terrestrial species** Some disturbance of riparian habitats will occur within the water storage area, although the majority of these habitats will be retained prior to inundation. Adjacent areas are considered to provide suitable habitats in the short-term. Protection and rehabilitation of vegetation and habitat offsets will provide compensatory habitat for this species.

This assessment indicates that the Project area does not contain important habitats for migratory species nor does it support an ecologically significant proportion of the population of any migratory species. Hence, the Project would have a negligible impact on migratory species listed under the EPBC Act.

28.4.4. Offsets

28.4.4.1. EPBC Act Policy

The Australian Government (in accordance with Draft EPBC Act Policy Statement 4.1 – Use of environmental offsets under the EPBC Act) defines environmental offsets as 'actions taken outside a development site that compensate for the impacts of that development - including direct, indirect or consequential impacts'. Environmental offsets provide compensation for those impacts which cannot be adequately reduced through avoidance and mitigation. They should be distinguished from 'mitigation', which refers to the range of actions that can be undertaken to reduce the level of impacts of a development (typically undertaken on-site). Actions that can be considered as environmental offsets are generally categorised into direct and indirect offsets. Direct offsets are aimed at on-ground maintenance and improvement of habitat or landscape values. They may include:

- long-term protection of existing habitat – including through the acquisition and inclusion of land in the conservation estate, and covenanting arrangements on private land;
- restoration or rehabilitation of existing degraded habitat; or
- re-establishing habitat.

Indirect offsets are the range of other actions that improve knowledge, understanding and management leading to improved conservation outcomes. They may include:

- implementation of recovery plan actions – including surveys;
- contributions to relevant research or education programs;
- removal of threatening processes;
- contributions to appropriate trust funds or banking schemes that can deliver direct offsets through a consolidation of funds and investment in priority areas; or
- on-going management activities such as monitoring, maintenance, preparation and implementation of management plans, etc.

Environmental offsets can be used under the EPBC Act to maintain or enhance the health, diversity and productivity of the environment as it relates to matters protected by the EPBC Act. The Australian Government has identified eight principles for the use of environmental offsets under the EPBC Act. These eight principles will be used to assess any proposed environmental offsets to ensure consistency, transparency and equity under the EPBC Act.

The Australian Government's position is that:

1) environmental offsets should be targeted to the matter protected by the EPBC Act that is being impacted;

2) a flexible approach should be taken to the design and use of environmental offsets to achieve long-term and certain conservation outcomes which are cost effective for proponents;

3) environmental offsets should deliver a real conservation outcome;

4) environmental offsets should be developed as a package of actions - which may include both direct and indirect offsets;

5) environmental offsets should, as a minimum, be commensurate with the magnitude of the impacts of the development and ideally deliver outcomes that are 'like for like';

6) environmental offsets should be located within the same general area as the development activity;

7) environmental offsets should be delivered in a timely manner and be long lasting; and

8) environmental offsets should be enforceable, monitored and audited.

A description of the proposed offset for Nathan Dam and Pipeline project and an assessment against the eight principles for the use of offsets under the EPBC Act are provided below.

28.4.4.2. Proposed offsets for Nathan Dam and Pipeline

Following assessment of impacts and application of mitigation strategies, residual impacts that were not of a minor nature were assessed as applying to the following matters of NES:

Threatened Ecological Communities:

- loss of up to 212.9 ha of remnant and regrowth Brigalow EC within the water storage area. Every effort will be made to avoid clearing of the Brigalow EC within the pipeline corridor.
- loss of 0.07 ha of Natural grasslands EC within the pipeline corridor. Every effort will be made to avoid the grassland patch by reducing the pipeline easement width.

Threatened Species:

- loss of 0.75 ha of habitat and one subpopulation of the Boggomoss Snail from Mt Rose station from inundation; and
- loss of 3398 ha of habitat for the Squatter Pigeon.

An offset applicable to each residual impact will be provided as part of the offsets package.

The Project also has the potential to impact on a number of threatened species that have been assessed as likely to occur within the Project area including Hairy-joint Grass, Curly-bark Wattle, Brigalow Scaly-foot and Australian Painted Snipe. The level of impact for each species was assessed as not significant. However, the proposed Project rehabilitation and offset strategies, which incorporate both State and Commonwealth requirements, will be of direct benefit to these species.

SunWater is currently working with Ecofund to develop the offset strategy. This includes identification of vegetation types and faunal habitats near the area of impact in order to identify compliant offset areas and any shortfalls. The strategy is intended to be structured in a similar strategic manner to that offered in the Connors River Dam and Pipelines EIS and Supplementary EIS. The aim of such a strategy is to maximise the environmental benefits by significantly enhancing the conservation estate in a large block or blocks rather than in a number of small, disconnected units. However there are some specific impacts that require a specific offset and cannot be satisfied by such a strategy. This includes some threatened flora that is only likely to be found on the pipeline alignment. Similarly GAB spring wetlands can only be protected where they specifically exist and the Boggomoss Snail is only known from certain locations. As such the offset approach is a mix of such specific components tied as closely as possible to the more strategic component. The components of the strategy will include:

- offsets related to Brigalow on properties or parts of properties purchased for the Project and otherwise on nearby properties. Ecofund has identified a number of potential properties on which it may be possible to secure the bulk of the necessary offset in one location.
- for Boggomoss Snail habitat, riparian areas of known and likely occupancy downstream from the dam will be protected via secure tenure as will any additional areas used in the translocation process;
- offsets for the potential cumulative impacts on Fitzroy River turtle will also include protection of downstream riparian areas and of nesting banks in Theodore Weir pool. A commitment to funding of catchment wide research into information gaps regarding the species is also included;
- protection of hiqh quality remnant vegetation and rehabilitation of non-remnant vegetation on Spring Creek which abuts Precipice National Park and Boggomoss Area No. 2 and includes the northern bank of the Dawson River downstream from the dam; and
- the proposed rehabilitation and restoration of the riparian zone on the northern side of the water storage to re-establish the east-west movement corridor will join Precipice National Park via the proposed protected area on Spring Creek station to the proposed protected habitat on Mt Rose station and the nearby north-south movement corridor.

While the threatened ecological community related to GAB spring wetlands is not impacted by the Project, offsets required under State policy will essentially allow implementation of recovery plan actions. This will include assessment for conservation rankings of the GAB spring wetlands and maintaining and improving the extent of GAB spring wetlands within areas of secure tenure obtained by SunWater.

Agreement will need to be reached with landowners where those properties have not or are not intended to be purchased as part of the Project. This includes downstream riparian landowners.

Habitat loss along the pipeline route will initially be mitigated by progressive rehabilitation of half the width of the easement immediately after construction has been completed. Rehabilitation will include the reinstatement and grading of topsoil, spreading of mulch and woody debris, planting of trees and shrubs that mimic those initially cleared and

spreading of appropriate grass seed mixtures over the remainder. The remaining 15 m operation easement will be kept free of trees and large shrubs and planted with appropriate grasses. Residual impacts will be addressed by offsets delivered as near as possible to the area of impact. This is particularly important considering the length of the pipeline.

In addition to direct offsets, SunWater is committed to a range of ongoing management activities which are consistent with the EPBC Act Policy Statement. Indirect offsets include the following:

- preparation of a Pest Management Plan to manage the occurrence of declared pests within the Project area during construction activities;
- preparation of a Weed Management Plan to minimise the potential for the spread and introduction of declared weeds during construction and operation;
- fencing and periodic exclusion of cattle to reduce the threat of cattle grazing and trampling on rehabilitation and offset areas; and
- on completion of construction, progressive rehabilitation of the construction site in areas that will not used for permanent infrastructure (house, parking, tracks to recreation area etc) or that are not inundated will be undertaken, by replacement of topsoil, contouring of the landform and revegetation as soon as possible after disturbance.

28.4.4.3. Assessment against EPBC Act offset principles

The proposed offset package will be consistent with the eight principles contained in Draft EPBC Act Policy Statement 4.1. An assessment against these principles is provided in Table 28-29.

Table 28-29 Assessment against the EPBC Act Offset Policy

Offset Principle	Project Response
1. Environmental offsets should be targeted to the matter protected by the EPBC Act that is being impacted.	The MNES which have residual impacts that require offset are listed threatened species and ecological communities. The species and communities have been identified as has the extent of impact upon each. Several species were not confirmed as present thus the impact on individuals remains "potential" while the impact on likely suitable habitat has been confirmed. SunWater's proposed offset strategy will specifically and directly address these matters through protection of suitable habitat via an appropriate form of secure tenure and by management measures that reduce acknowledged threats. Precise mechanisms with respect to tenure are currently undecided, but a range of options are available, including statutory covenant, nature refuge, voluntary conservation agreement and voluntary declaration as an area of high conservation value.
2. A flexible approach should be taken to the design and use of environmental offsets to achieve long-term and certain conservation outcomes which are cost effective for proponents.	The design of the offset strategy for the Project focuses initially on satisfying the Queensland Policy for Vegetation Management Offsets. This is due to the more deterministic nature of the policy and recognition that offsets under this policy directly relate to offsets required under the policy of the Australian Government. Co-location of offsets will be assumed. For example protection of areas of downstream riparian zone may satisfy the watercourse component of the State VM Act as well as the Commonwealth need for offsets regarding Boggomoss Snail and Fitzroy River turtle habitat. SunWater will aim to concentrate offsets in a contained geographic area and to link areas of remaining suitable habitat in order to maximise the environmental benefit obtained from the offsets. This will allow management actions within those areas to be cost effective.
3. Environmental offsets should deliver a real conservation outcome.	The protection of significant areas of vegetation which is currently unprotected and subject to agricultural pressures is a real conservation outcome. The offset areas will be managed essentially as environmental reserves in perpetuity. As the proposed offset areas will as far as possible be located adjacent to the impact area, there will be a direct and tangible benefit to local flora and fauna populations and an associated improvement in water quality and riparian zone condition.
4. Environmental offsets should be developed as a package of actions, which may include both direct and indirect offsets.	The emphasis of the offset package is direct habitat offsets, supported by a range of sympathetic land management initiatives such as pest control and selective stock exclusion or grazing pressure reduction. Indirect offsets include the development of weed and pest vertebrate management plans, a thorough range of monitoring programs and catchment wide research in the case of Fitzroy River Turtle.
5. As a minimum, environmental offsets should be commensurate with the magnitude of the impacts of the development and ideally deliver outcomes that are 'like for like'.	The offset proposed will be commensurate with the magnitude of impact, which, from the point of view of MNES relates to habitat for threatened flora and fauna species. It is intended that an offset area be provided which is substantially greater than the area impacted by the Project. The principle of 'like for like' which requires offsets to be targeted towards the specific environmental value being impacted by a development is a primary driver of the offset package. The proposed offset will as far as possible be located immediately adjacent to and downstream of the water storage area and as such is likely to support a very similar suite of biotic and abiotic features to those within the impact area.
6. Environmental offsets should be located within the same general area as the development activity.	As noted above, this is a foundation of the strategy.

Offset Principle	Project Response
7. Environmental offsets should be delivered in a timely manner and be long lasting.	Offsets will be finally identified and secured directly following project approval. This process has commenced through employment of Ecofund to develop the strategy. It is envisaged that impacts to landholders adjacent to the water storage area or pipeline could be minimised by identifying and agreeing on land purchase or tenure required for offsets at the same time as finalising purchase or lease agreements related to direct construction or flood buffer impacts. However it is envisaged that some specific offsets may be difficult to obtain so a reasonable timeframe should be allowed for that process. The watercourse offsets necessary as a result of impacts on the Dawson River is one such area and this offset directly relates to the Fitzroy River turtle and potential habitat for a number of threatened and migratory species. Tenure agreements will ensure the offset will survive in perpetuity. Ecofund has identified that the policy can be met but just how it is met will depend on landholder negotiations.
8. Environmental offsets should be enforceable, monitored and audited.	The requisite offset package can be attached to approval conditions which are enforceable. Secure tenure is a requirement of offset and the form of tenure will be finalised through agreement with Federal and State authorities. The offset areas will require ongoing management and will be monitored over the long term. The final offset package will be fully developed following project approval. The offset strategy will include clearly articulated measures of success, primarily around the achievement of habitat condition milestones. Management plans will be developed for each offset area and will direct the long term monitoring programs.

28.5. Environmental flows – an MNES context

This section has been prepared to summarise detailed information provided in Chapters 12, 13, 14, 16 and earlier parts of Chapter 28 above, as they relate to MNES only. It is recognised that environmental flow statistics can often be difficult to interpret, especially if the terms and statistics referred to are not used by the reader on a regular basis. As such, the aim of this section is to provide a focused discussion and assessment of potential changes to flows by revisiting terminology and statistics provided throughout the EIS, and provide further explanation of their meaning and use, in the context of MNES.

28.5.1. Flows as they relate to MNES

In order to understand how changes to flow conditions downstream of Nathan Dam may influence MNES, it is important to understand which particular "matters" could be affected and how.

Of all the MNES, three have been identified which could potentially be impacted by changes associated with downstream flow conditions. These include:

- GBR (as a World Heritage Area and a National Heritage Place);
- Boggomoss snail; and
- Fitzroy River turtle.

28.5.1.1. GBR

With respect to the GBR, the Fitzroy River Basin discharges into the GBRWHA at Keppel Bay, south-east of Rockhampton, approximately 620 km downstream of the Project (Figure 28-23).

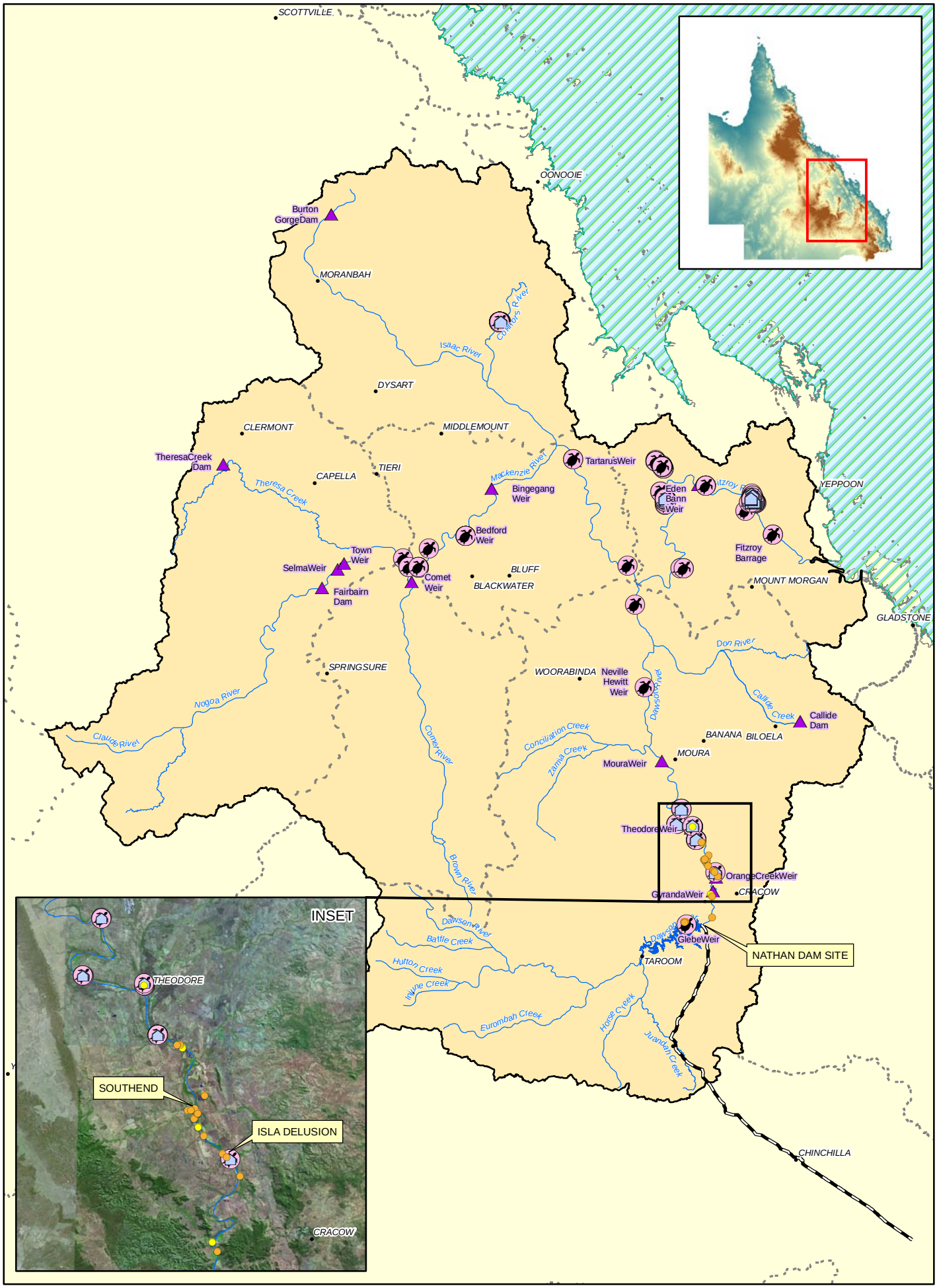
Within the technical reports (DNR, 1998) prepared for the Fitzroy River Water Allocation and Management Planning (WAMP) process, members of the Technical Advisory Panel (TAP) highlighted that river discharge can have an important effect on the physical and chemical characteristics of estuaries and near-shore waters (e.g. geomorphology, salinity and turbidity), which in turn are important factors influencing the distribution and abundance of fish and crustaceans (DNR, 1998, p.6.).

Utilising the DNR (1998) technical reports, flow conditions defined as important to the GBR and adopted herein include the regular small floods which provide flushing of the estuary. Table 28-30 provides a brief description of the performance indicator used to represent flows important for the GBR, its ecological significance and adopted flow volume.

Table 28-30 Adopted flows for GBR

Statistics	Description	Purpose	Flow
Minor flood flow	2yr ARI flow	Small flood flows to flush the estuarine environment	211,455 ML/day

*ARI =Average Recurrence Interval



LEGEND

- Town
- Weir Locations
- Proposed Pipeline
- Major Watercourses
- Catchment Boundaries
- Full Supply Level (185.3m AHD)
- Fitzroy Basin
- World Heritage Area
- Live Snails
- Snail Shells
- Turtle Nest Recorded
- Turtle Recorded

Projection: GDA94

Figure 28-18

0 10 20 40 Kilometres

N

Scale 1:3,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Matters of national environmental significance potentially impacted by changes to the flow regime

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28.5.1.2. Boggomoss Snail

Boggomoss snails currently utilise riparian areas along the Dawson River which become inundated with the rise and fall of this largely ephemeral river. The riparian zone supports moist habitat with scattered fallen logs which provide the snail with shelter and foraging sites. Riparian populations are threatened by floods which scour the snail's microhabitat and even drown the snails if there is extended submergence, and drying of the riparian habitat during drought (BAAM, 2010). The relationship between the Boggomoss snail and flows then relates to the maintenance of riparian vegetation as habitat and changes to flood flows.

The degree to which riparian vegetation relies on flows depends on species composition and water availability. As will be demonstrated in later sections of this chapter, the flows associated with riparian vegetation are typically medium to large in scale and tend to occur relatively infrequently. Riparian vegetation therefore can also rely on a number of other water sources including groundwater and rainfall.

There are six breeding sub-populations of the Boggomoss Snail now known from Mt Rose Station, Isla-Delusion Camping Reserve, Southend Station and Gyranda. With the exception of Mt Rose, these sites all occur within the Dawson River riparian zone downstream of Nathan Gorge. The Gyranda sub-population is located within the area around Gyranda Weir, while the Isla-Delusion Camping Reserve and Southend Station sub-populations (Figure 28-23) are located between Orange Creek Weir and the upper reaches of Theodore Weir.

In terms of long-term population viability, the largest and most intact habitat systems occur downstream of the Isla-Delusion Crossing, particularly on the properties Lagoona (which is a part of the Isla-Delusion habitat) and Southend within the riparian zone. A mix of adult and sub-adult snails has been reported from all of the known sub-populations, indicating that conditions remain suitable for recruitment of individuals to those populations.

It is for this reason the following assessment of potential change to flows for this species, has focused on the riparian reach between Orange Creek Weir and the upper reaches of Theodore Weir. Two cross sections of the Dawson River within this reach (Figure 28-19 and Figure 28-20) have been used to establish the volume of water required to mimic "riparian flows" such that an assessment of potential changes can be undertaken. Table 28-31 provides a brief description of the performance indicators used to represent flows important for the Boggomoss Snail, their ecological significance and adopted flow volume.

Table 28-31 Adopted flows for Boggomoss Snail

Statistics	Description	Purpose	Isla-Delusion	Southend
Half bankfull flow	Mid-channel flows	Important for the riparian zone	4,600 ML/day	6,350 ML/day
Bankfull flow	Top of bank	Important for the riparian zone	48,400ML/day	45,400 ML/day

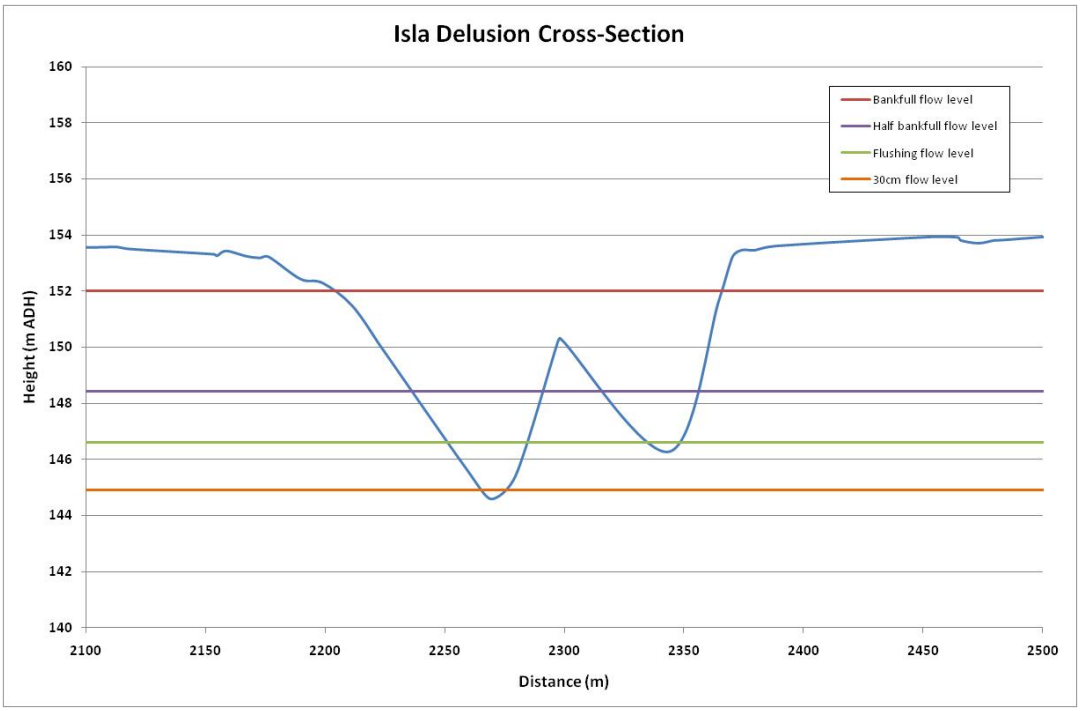


Figure 28-19 Isla-Delusion cross section used for hydrological modelling

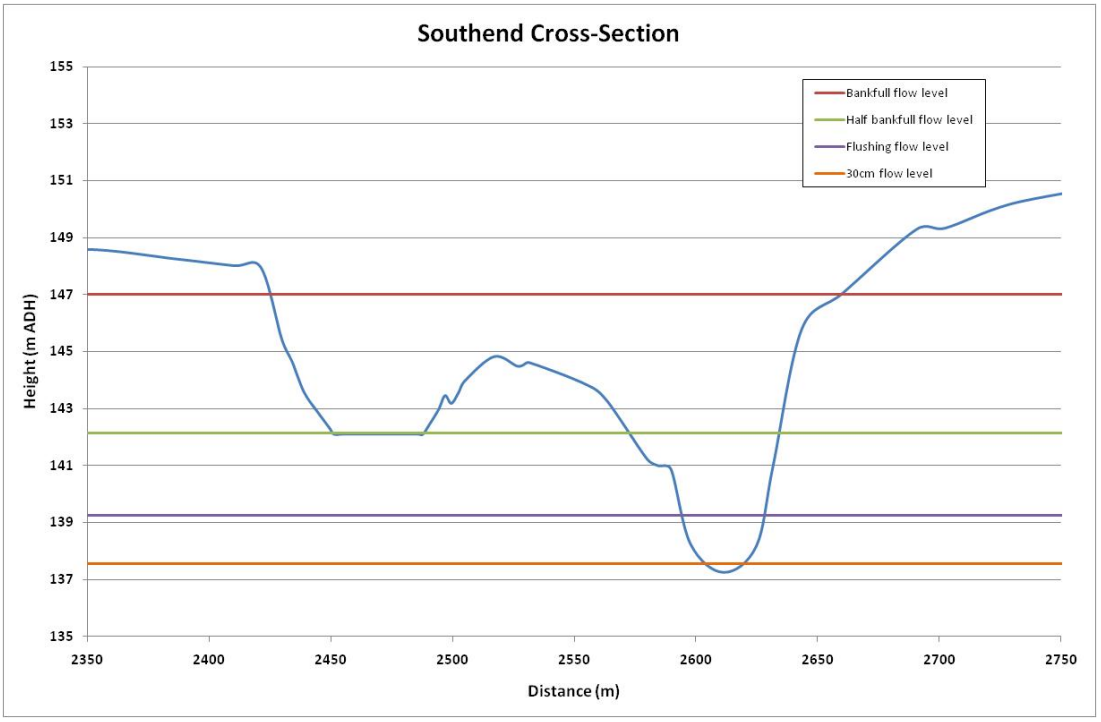


Figure 28-20 Southend cross section used for hydrological modelling

28.5.1.3. Fitzroy River Turtle

The Fitzroy River turtle is endemic to the natural permanent riverine habitats of the middle and lower Fitzroy catchment (Limpus *et al.* 2007). Within the Dawson River, the Fitzroy River turtle has been located downstream of Orange Creek Weir and downstream, within and around the Theodore Weir storage, upstream of the Neville Hewitt Weir storage and upstream of the Dawson / Mackenzie River junction (Figure 28-18).

The Fitzroy River turtle occurs in flowing rivers with large deep pools with rocky, gravelly or sand substrate, connected by shallow riffles (DEWHA 2008). Under low flow events, or as riffle zones become seasonally ephemeral (i.e. dry completely), the Fitzroy River turtle retreat to deeper sections of pool habitats, or even isolated waterholes, adjacent to riffle zones (Limpus *et al.* 2007, Tucker *et al.* 2001).

As riffle zones throughout most of the range of the Fitzroy River turtle, including in the Dawson River, are also not present all of the time, this species should not be considered to be a riffle zone specialist; rather, they exploit this habitat to forage for abundant food sources such as benthic invertebrates and algae during the wet season and early dry season (Limpus *et al.* 2007). This allows the turtles to take up nutrients and build fat reserves for the dry season, which is essential for preparing to breed (Limpus *et al.* 2007). Therefore, while large, slow flowing pools can support populations of the Fitzroy River turtle, they are likely to have a lower carrying capacity than reaches containing riffle zones (Limpus *et al.* 2007).

As such flow indicators for this species include:

- 10 cm flows to maintain water quality within pools and for prey species that inhabit riffle zones;
- 30 cm flows to facilitate movement between pools; and
- flushing flows to maintain water quality.

Nesting in Fitzroy River turtle occurs between September and December (Limpus *et al.* 2007). There is little information regarding recruitment within the Dawson however poor recruitment of juveniles into the Fitzroy River population in recent years has been noted with the population consisting primarily of ageing adults (Limpus *et al.* 2007). It should be noted however, that the population of Fitzroy River turtles in the shallow and slow-flowing Fitzroy Barrage impoundment is a well-functioning population, with several nesting banks available (Limpus *et al.* 2007, frc environmental 2007b). Conversely, populations at other sites in the Fitzroy River downstream of the study area, are not functioning as well, and reproductive success is low (Limpus *et al.* 2007).

Current known nesting sites within the Dawson River are located downstream of Orange Creek Weir and downstream, within and upstream of Theodore Weir (Figure 28-18). It is for this reason the following assessment of potential change to flows for this species, has also focused on the regulated reach between Orange Creek Weir and the upper reaches of Theodore Weir. The same cross sections of the Dawson River within this reach (Figure 28-19 and Figure 28-20) have been used to establish the volume of water required to mimic 10, 30 cm and flushing flow such that an assessment of potential changes can be undertaken.

Table 28-32 provides a brief description of the performance indicators used to represent flows important for the Fitzroy River turtle, their ecological significance and adopted flow volume.

Table 28-32 Adopted flows for Fitzroy River turtle

Statistics	Description	Purpose	Isla-Delusion	Southend
10 cm flow	The flow volume required to maintain 10 cm of flow in the channel	Critical for water quality	14 ML/day	11 ML/day
30 cm flow	The flow volume required to maintain 30 cm of flow in the channel	Critical for river connectivity and fish movement	41 ML/day	34 ML/day
Flushing Flows	Flows vary between location but generally between 1.5-2 m	Critical for water quality	1,600 ML/day	1,100 ML/day

With an understanding of which MNES are influenced by flows and how they relate to specific flow conditions, it is then necessary to understand how potential changes to these flows are modelled and assessed.

28.5.2. Understanding environmental flow statistics

Hydrologists use a range of statistics to quantify flow regimes and how they change under different operating scenarios. Some of these statistics are specifically related to environmental flows and species requirements and are generated using a number of modelling tools.

28.5.2.1. Flow models

For the purpose of determining environmental statistics for the Project, the DERM IQQM has been used to assess changes to streamflow and water usage.

The DERM IQQM is a hydrologic model that simulates the catchment's response to climate conditions over a selected historical period. For this catchment the IQQM uses a historic simulation period of 96 years from 1900 to 1995 (Chapter 14).

Three scenarios are discussed throughout the EIS including: Pre-development, Full Entitlement and 'With Dam'.

The Pre-development scenario represents flows within the system with all dams and water infrastructure removed from the model and with no water extracted from the system. This provides information on the flow regime of the system prior to any water resource development and is used to represent the natural condition of the catchment.

The Full Entitlement scenario incorporates all water resource development within the catchment which existed at the time the model was developed, i.e. all dams, weirs, off stream storages, associated water infrastructure and all water entitlements. It assumes full utilisation of all existing water entitlements regardless of the actual degree of utilisation. This provides information on the committed entitlements and represents the approved level of water resource use in the catchment and is the base case for assessment.

It is not possible to use actual utilisation of entitlements because these vary from year to year and farm to farm. So, to ensure an ecologically conservative modelling approach for predictive purposes, full entitlement use remains incorporated.

In order to understand the likely flow regime after the Nathan Dam is operational, as compared to the flows in the river under the current levels of development, an additional model is required. The Full Entitlement model was therefore adjusted to include the dam and its preliminary operational strategy. This case is referred to as the 'With Dam' scenario.

The model can be used to extract numerous statistics (mean and median flows, frequency analysis) in various forms such as flow duration curves, tables and graphs. It is important that an array of statistics be considered in order to build a complete picture of potential changes to flows.

28.5.2.2. Interpreting flow statistics

There are many statistics generated and assessed to determine potential changes to flow conditions. Within this section, three statistics have been chosen to demonstrate:

- how flow might be expected to vary at a location over an extended period of time (Flow Duration Curves);
- seasonality (Frequency Graphs); and
- potential changes to specific flow events throughout the modelled simulation period (Spells Analysis).

As outlined above, it is important not to assess any one statistic in isolation as this can provide a skewed view of impacts. For example, at first glance the daily flow duration curve presented below (Figure 28-21) appears to show a large change to flows that occur between 54% and 100% of the time. When considered within the context of depth, this graph is indicating that there will be a potential change from a constant base flow depth of approximately 10 cm for the Full Entitlements scenario to 30 cm for the 'With Dam' scenario (Figure 28-22).

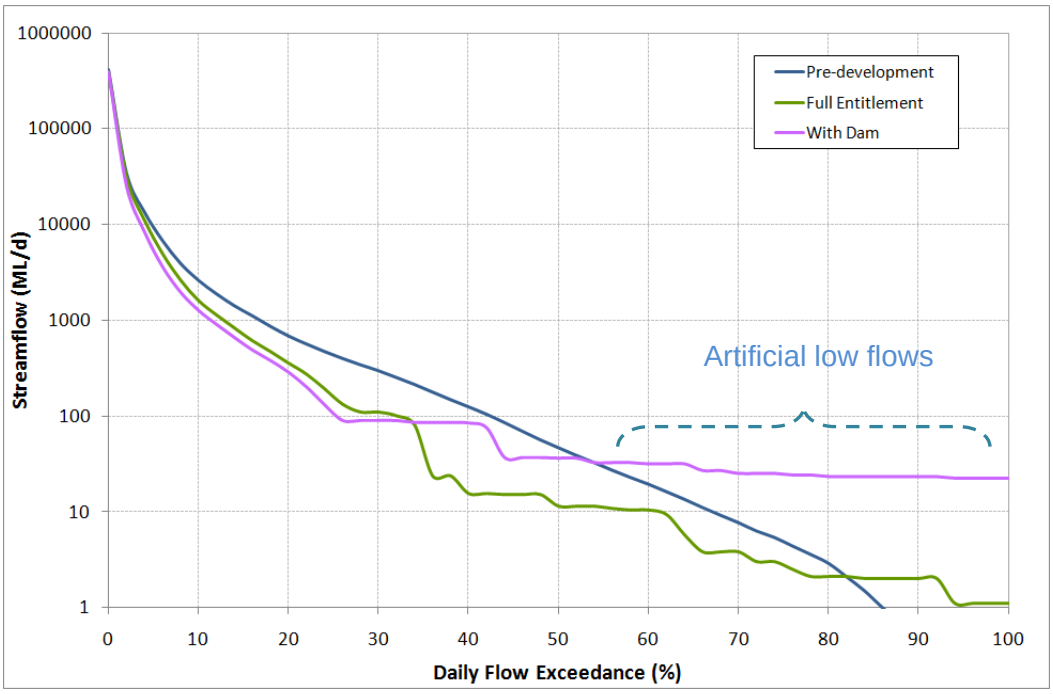


Figure 28-21 Example daily flow duration curve

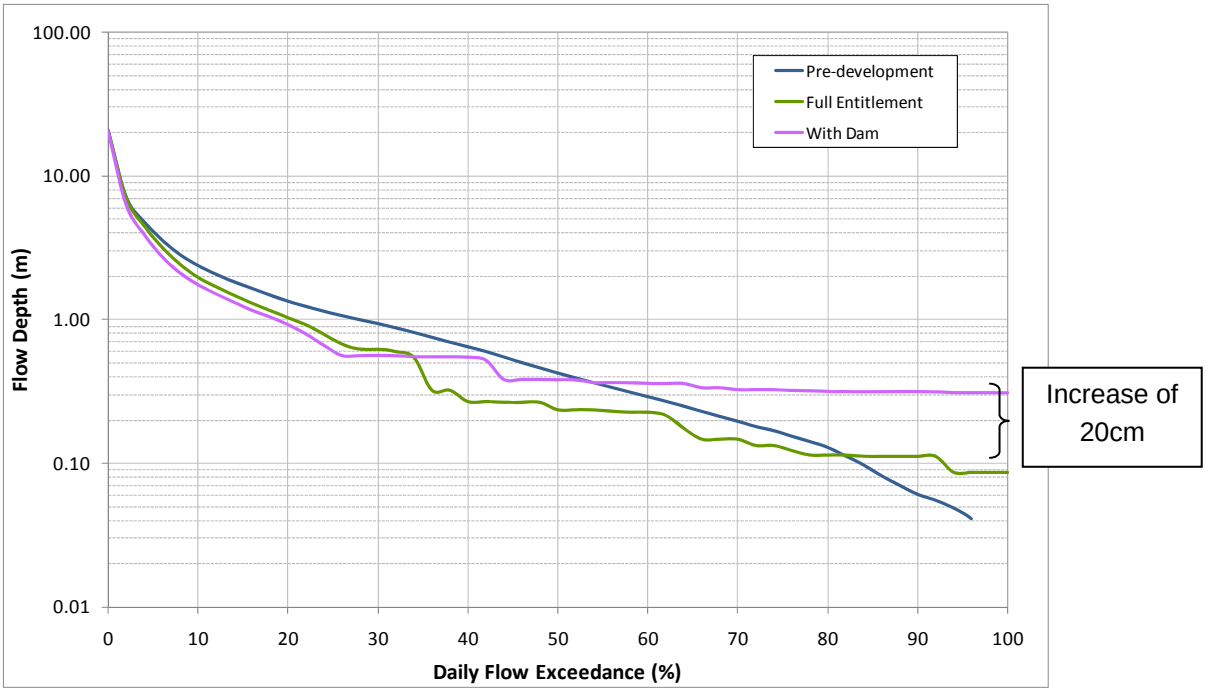


Figure 28-22 Example daily flow depth exceedance

Flow Duration Curves

To quantify potential impacts across a flow regime, streamflow is modelled for different operating scenarios over a long period of time. The simulation period modelled for this project is 96 years. In order to visualise these potential impacts across the full flow regime, flow duration curves are used. Flow duration curves demonstrate the percentage of time that the stream flow equals or exceeds a particular discharge over a long period of time. Utilising the End of Dawson River flow duration curve as an example (**Figure** 28-23), this figure highlights that at this point in the river, large flood flows occur infrequently (<5%) and have been largely unaffected by regulation reflected in the overlapping Pre-development (dark blue line) and Full Entitlement lines (green line). As flows decrease there is a greater proportional change as reflected in the separation of the two modelled scenarios.

Flow duration curves can be used as an indicator of how flow might be expected to vary at a location over an extended period of time and are useful when comparing the overall changes in flow regime between different scenarios. These graphs (curves) are presented on a log scale so as not to mask differences in smaller flows when using a linear scale.

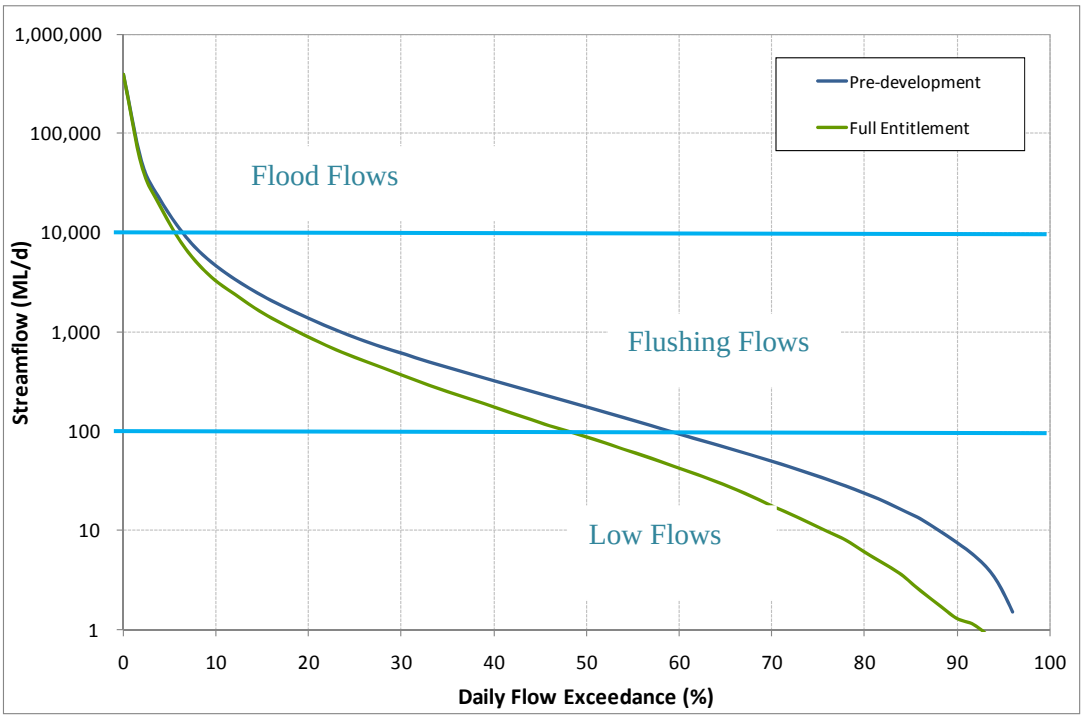


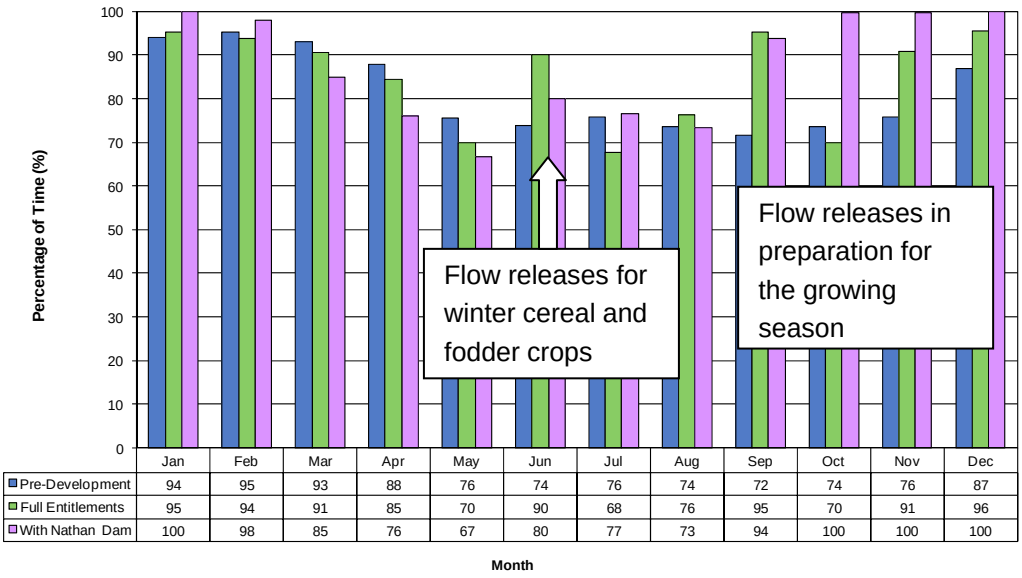
Figure 28-23 End of Dawson River flow duration curve

Frequency tables and graphs

The frequency analysis tables and graphs used within this section enable an assessment of potential changes to specific flows (10 cm, 30 cm, etc.) over a year. This allows for an assessment of potential impacts to seasonality.

For example, **Figure** 28-24 presents a frequency analysis of 10 cm flows, showing the percentage of time per month that flows are equal to or greater than 10 cm. The Pre-development series displays a strong seasonal variation, with flow greater than 10 cm for a higher percentage of time during the wet season (November to April) than during the dry season

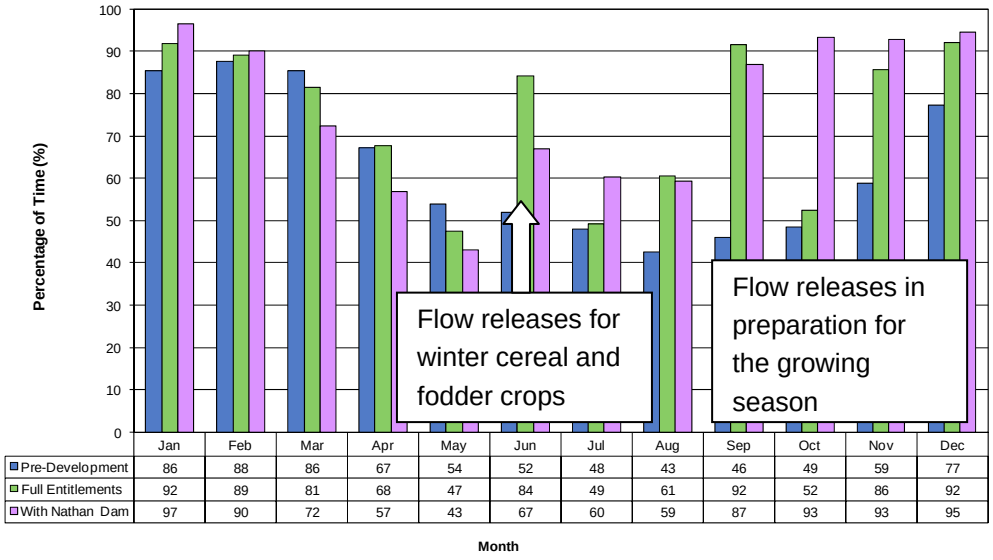
(May to October). This seasonal variation is altered under the Full Entitlement and With Dam scenarios due to the influence of regulation within the system, e.g. releases for irrigators and attenuation of flow caused by the dam taking water into storage.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	94	95	93	88	76	74	76	74	72	74	76	87
Full Entitlements	95	94	91	85	70	90	68	76	95	70	91	96
With Nathan Dam	100	98	85	76	67	80	77	73	94	100	100	100

Figure 28-24 Frequency analysis: 10 cm flows

Figure 28-25 presents a frequency analysis of 30 cm flows, showing the percentage of time per month that flows are equal to or greater than 30 cm. Again, the Pre-development series displays a strong seasonal variation. This seasonality of flow is generally maintained through January to May under the Full Entitlement and With Dam scenarios but is altered from June to December.

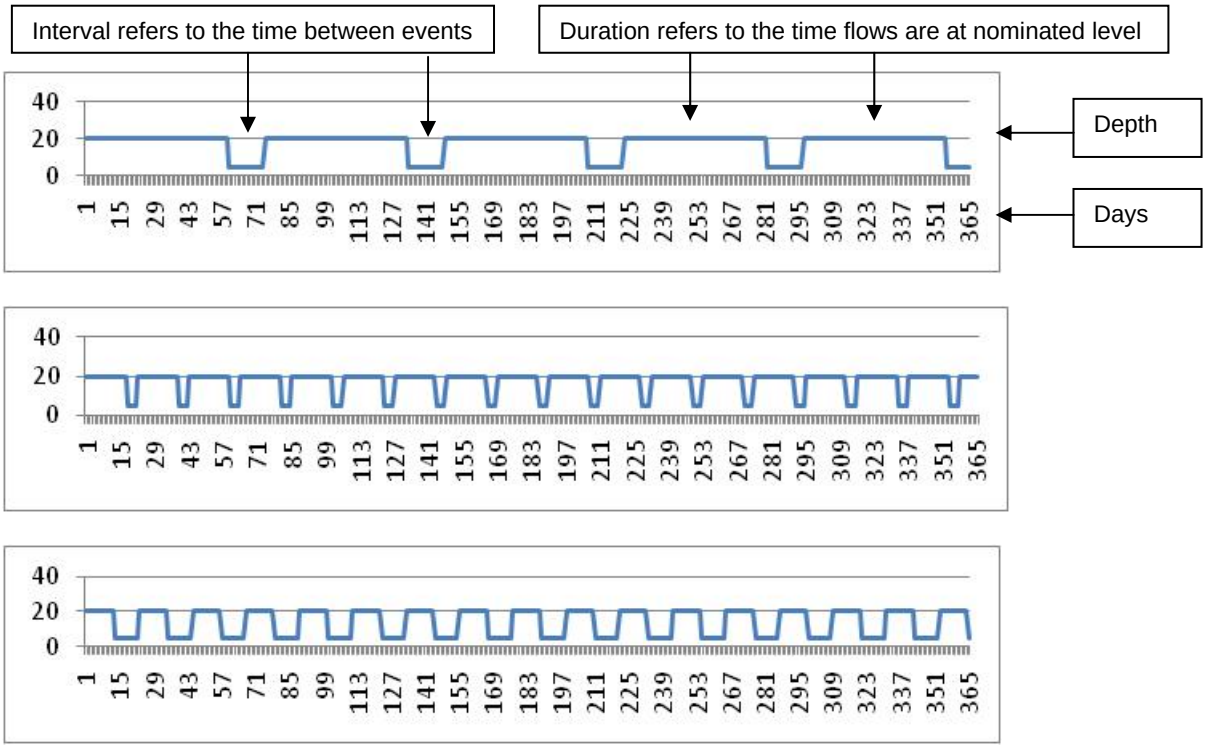


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	86	88	86	67	54	52	48	43	46	49	59	77
Full Entitlements	92	89	81	68	47	84	49	61	92	52	86	92
With Nathan Dam	97	90	72	57	43	67	60	59	87	93	93	95

Figure 28-25 Frequency analysis: 30 cm flows

Spells Analysis

The spells analysis allows an assessment of potential changes to specific flow events throughout the modelled simulation period. The spells analysis measures the frequency, duration, number of days, etc. that flows are at or above a specified threshold. As depicted below, interval relates to the period between flow events, while duration reflects the time flows are at the specified level.



For example, Table 28-33 presents a generic spells analysis of 10 cm flows or greater, showing the number of flow events, mean spell duration (i.e. the average duration of 10 cm or greater flow events) and mean spell interval (i.e. the average time between 10 cm or greater flow events).

Under the Full Entitlement scenario the number of events has increased from Pre-development, although the duration of the events has decreased slightly. The average time between the flow events has also decreased slightly meaning the average time when flows are less than 10 cm has reduced. Under the With Dam scenario the number of events decreases significantly relative to the full entitlement scenario although the duration increases. This indicates that a number of the 10 cm or greater flow events are combining to form longer flow events. This is primarily due to the influence of regulation within the system, e.g. water releases for irrigators, dam maintenance releases and fishway releases.

Table 28-33 Spells analysis (10 cm flows)

Scenario	No. of events	Mean Spell duration (days)	Mean Spell interval (days)
Pre-development	482	59	14
Full Entitlement	520	57	10
With Dam	417	73	11

Table 28-34 presents a spells analysis of 30 cm or greater flows. Under the Full Entitlement scenario the number of events has increased compared to Pre-development, although the duration of the events has increased slightly and the average time between the flow events has decreased. Under the With Dam scenario the number of events decreases significantly, while the duration and interval increases. Again, this indicates that a number of the flow events are combining to form longer flow events.

Table 28-34 Spells analysis (30 cm flows)

Scenario	No. of events	Mean Spell duration (days)	Mean Spell interval (days)
Pre-development	741	30	18
Full Entitlement	792	33	11
With Dam	609	44	14

When interpreting flow statistics within a spells analysis, it is also important to understand how dam operations can alter flow statistics. In the case of large flood flows, the degree of flooding will be tempered by managing flow release during these events, such that the peak is reduced (Figure 28-26). Reducing the peak of the flood (or the maximum extent of flooding) extends the duration of the event, in this instance from an average from 5 days to 7 days. It also reduces the number of events that are likely to meet the trigger value for the bankfull flow statistic (Figure 28-27). Whilst the same volume of water may pass by the dam, the managed approach to flow releases means that these flows may pass by at a lower level, reflecting the role of dams in downstream flood mitigation.

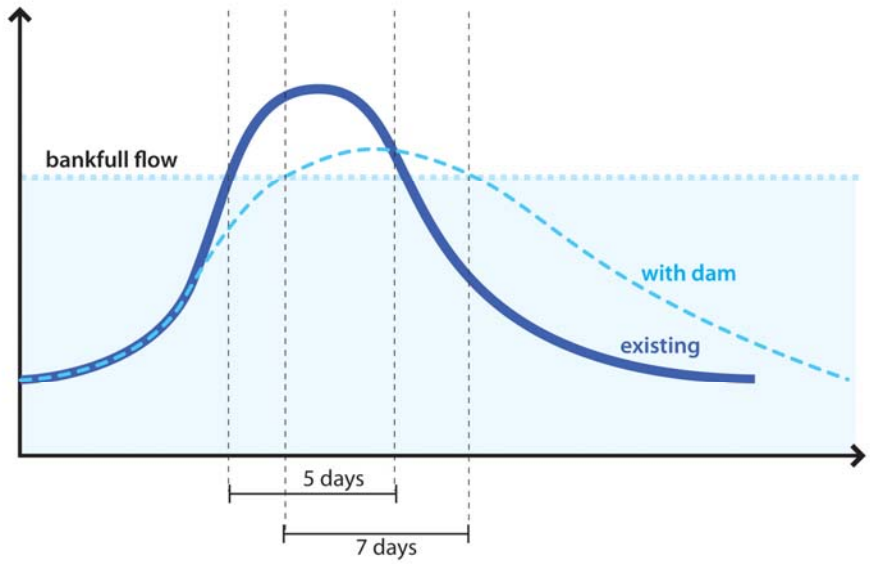


Figure 28-26 Example of reduced flood peaks with increased duration

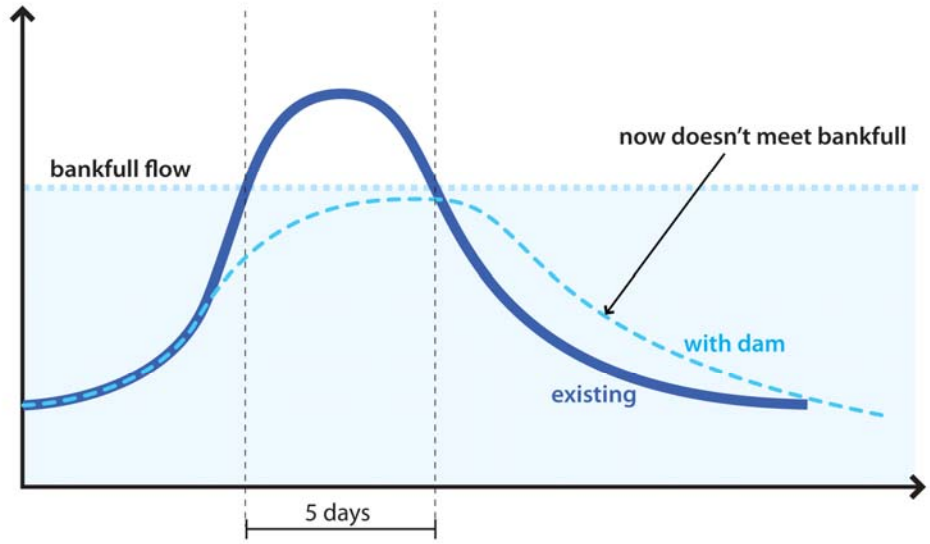


Figure 28-27 Example of reduced flood peaks no longer reaching trigger threshold

28.5.2.3. Relationship with WRP Environmental Flow Objectives

In Queensland water resources development is governed under the *Water Act 2000* and subordinate plans for each basin, called a Water Resource Plan (WRP). The relevant WRP for the Nathan Dam proposal is the *Water Resource (Fitzroy Basin) Plan 1999.*

The key aim of a WRP is to achieve the sustainable management of water resources within a catchment. In order to do this a balance between the water needs of agriculture, towns and industry and the needs of the environment must be found. The *Water Resource (Fitzroy Basin) Plan 1999* (WRP) makes provision for 'environmental water requirements for natural ecosystems'.

As part of this process the WRP sets out a suite of flow statistics, called Environmental Flow Objectives (EFOs) designed to achieve WRP objectives by supplying environmental needs. Their aim is to maintain key flow conditions within the catchment in order to ensure ecosystem health. The performance indicators cover a range of no flow, low flow, medium to high flow and seasonal flow statistics and are used to compare the current or proposed river flow with the pre-development flow at specific locations, or reporting nodes. The EFOs are set drawing from the recommendations of the WRP Technical Advisory Panel (TAP) and should be considered collectively, as ecosystems respond to the entire flow regime, not just individual components.

The TAP established for the 1999 WRP consisted of a range of environmental and other technical specialists, who are expert in their field and have extensive local knowledge in the Fitzroy Basin. Several workshops (including a field investigation of the Fitzroy Basin) of the TAP were held in the lead-up to the preparation of the Technical Reports (DNR 1998, p. 6).

Table 28-35 provides a comparison of the MNES statistics described in Section 28.5.1 against WRP EFOs.

Table 28-35 MNES flow statistics and WRP EFO comparison

Species	MNES Statistics	Description	Purpose	Relationship with WRP EFOs
Boggomoss Snail	Half bankfull flow	Mid-channel flows	Important for the riparian zone	Same as in-channel riparian zone statistic
Boggomoss Snail	Bankfull flow	Full bank flow	Important for the riparian zone	Same as Upper riparian zone statistic
Fitzroy River turtle	10 cm flow	The flow volume required to maintain 10 cm of flow in the channel	Critical for water quality	N/A
Fitzroy River turtle	30 cm flow	The flow volume required to maintain 30 cm of flow in the channel	Critical for river connectivity and fish movement	This is similar to the Seasonal Baseflow
Fitzroy River turtle	Flushing Flows	Flows vary between location but generally between 1.5-2 m	Critical for water quality	Same volume as post winter flow statistic
GBRWHA	Marine/Estuarine flushing flow	This is equivalent to a 1 in 2 year flood event.	Flushing flow to maintain	Marine and Estuarine Process Statistic

28.5.3. Existing flow conditions in the Dawson River

To understanding the environment in which the three MNES currently exist, a brief description of the Dawson River and its relationship with the Fitzroy Basin is provided below.

The Dawson River is located in the southern corner of the Fitzroy Basin. The Fitzroy Basin has a total catchment area of approximately 142,600 km^2 and consists of six major sub-catchments: Isaac-Connors, Mackenzie, Dawson, Nogoa, Comet and Fitzroy.

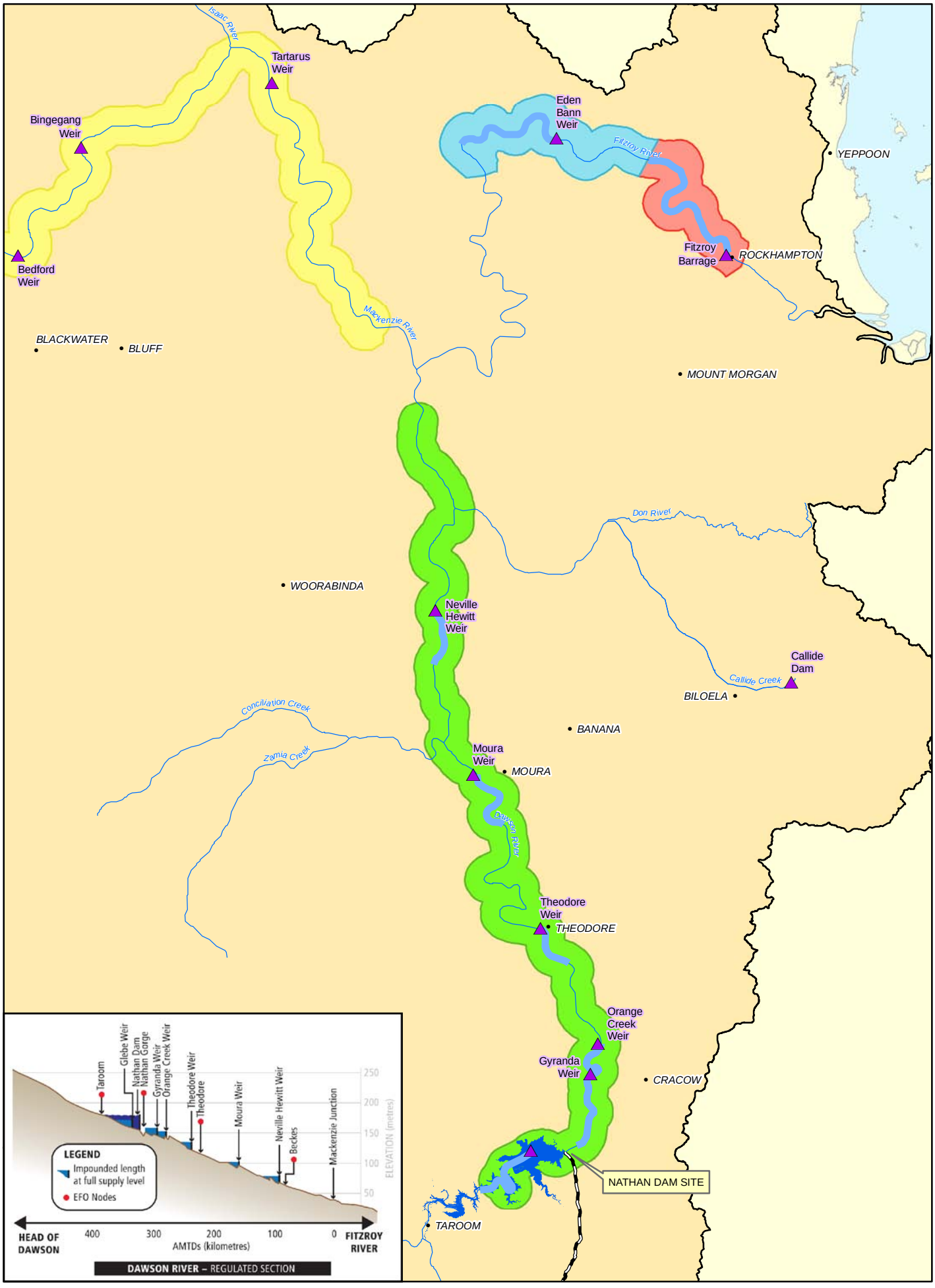
The dam site is located on the upper Dawson River at AMTD 315.3 km, measured along the river from the confluence of Dawson River and Fitzroy River, and is 35 km directly north east of Taroom. From the dam site, the Dawson River flows north, joining the Fitzroy River near Duaringa, AMTD 310.3 km from the Fitzroy River mouth. The dam site is therefore approximately 626 river kilometres from the river mouth. The Nathan Dam catchment has a total area of approximately 23,185 km^2, which is approximately 16% of the total Fitzroy Basin.

There are approximately 64 creeks and rivers flowing into the Dawson River, with the major tributaries upstream of the dam site being Baffle Creek, Eurombah Creek, Hutton Creek, Horse Creek, Palm Creek and Juandah Creek. The major tributaries downstream of the dam site are the Don River, Callide Creek, Castle Creek, Mimosa Creek (including Conciliation Creek and Zamia Creek), Banana Creek and Bone Creek.

Rainfall across the catchment varies seasonally, with higher rainfall occurring in late spring and summer. Rainfall and runoff are highly variable and the catchment has experienced frequent periods of drought and flooding.

Approximately 10.9 km upstream of the Project site there is an existing storage, Glebe Weir, which has a full supply volume of 17,700 ML. This weir will be submerged once the dam is completed. There are no instream storages upstream of Glebe Weir, although there are multiple small storages along the Dawson River downstream of the Project site, as detailed in **Chapter 14**.

The Dawson River, downstream of Glebe Weir, is a highly regulated river. The current Dawson Valley Water Supply Scheme extends along the Dawson River from the upstream limit of Glebe Weir to the downstream limit of the Boolburra waterhole, approximately 18 km upstream of the Fitzroy River junction (DNRW, 2009). The regulated reach covers a total length of 338.1 km while the total impounded extent from existing storages is 138.5 km, or approximately 41% of the regulated reach Figure 28-28. With the dam in place this will increase by 8%.



LEGEND

- Weir Locations
- Proposed Pipeline
- Major Watercourses
- Weir Upstream Limits
- Full Supply Level (185.3 m AHD)
- Fitzroy Basin

Supplemented Water Supply Scheme

- Nogoa Mackenzie
- Dawson Valley
- Lower Fitzroy
- Fitzroy Barrage

Projection: GDA94

Figure 28-28

0 10 20 40
Kilometres

N

Scale 1:1,300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Regulated section of the Dawson/Fitzroy Rivers

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28.5.3.1. How water is released/utilised

Water products are available as either supplemented or unsupplemented water entitlements. Supplemented water entitlement holders are supplied with water from water storages. As defined by DERM (http://www.derm.qld.gov.au/water/trading/types.html):

> "A supplemented water supply is one which is made more reliable by releases of stored water, for example from dams. Supplemented supplies are managed by water supply scheme operators, for example SunWater."
>
> "An unsupplemented supply is one that is not boosted by releases of stored water. Unsupplemented supplies are managed by the department."

Supplemented water entitlement holders may draw directly from a water storage via a pipeline or water may be released into the natural watercourse and the entitlement holder will extract (pump) from the watercourse. If water is delivered via the watercourse it is generally released as a low constant flow if it is to service high priority users (town water supply or industry), although a pulse of water may be occasionally released (more applicable to irrigators with seasonal demands). Additional water may also need to be released in order to account for transmission losses incurred along the way to the extraction location. (Transmission losses include evaporation and seepage within the channel).

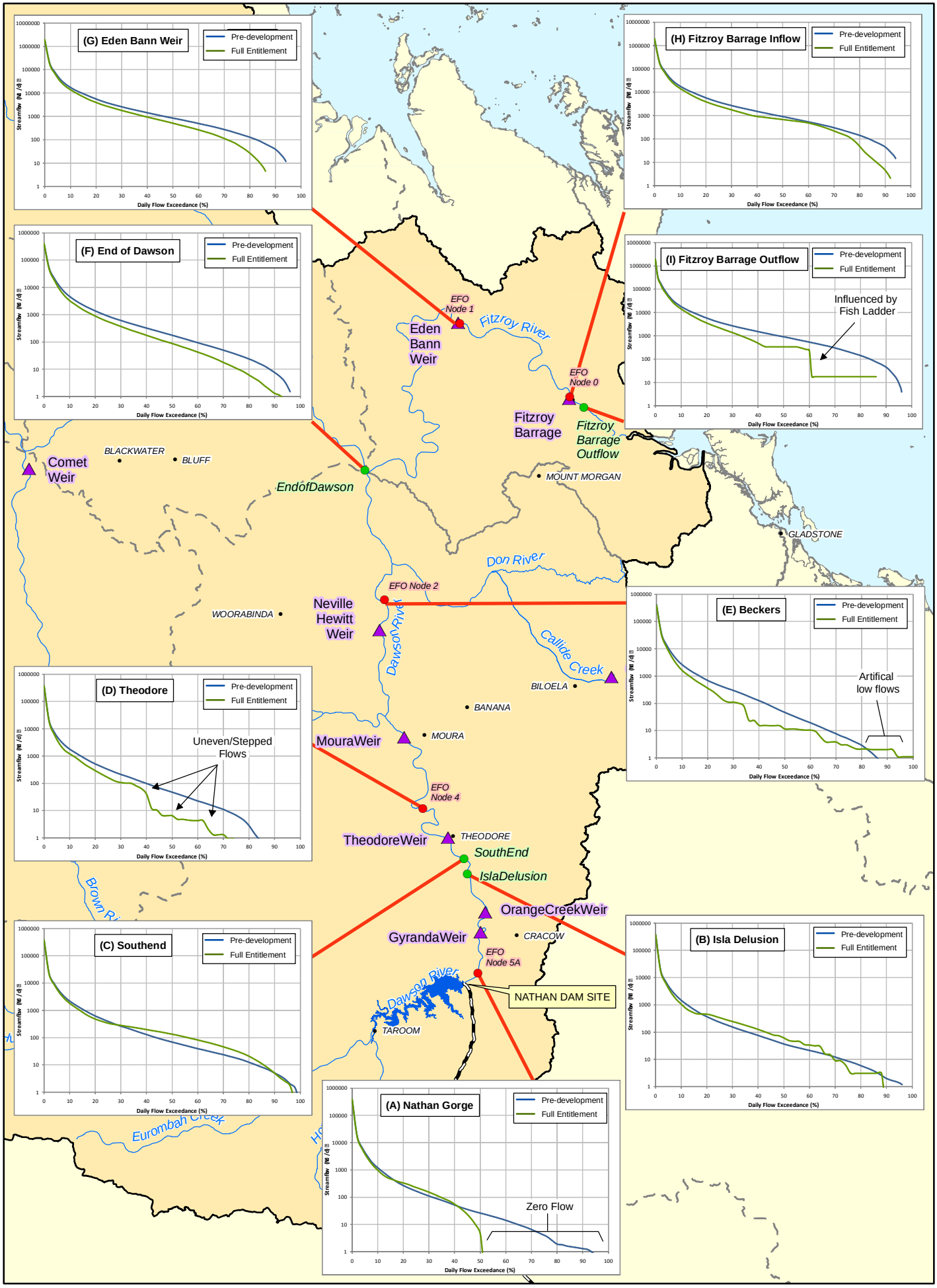
Within the Dawson catchment, flows released downstream for users tend to reflect the peak growing seasons. As has been demonstrated in the flow duration curves for the Dawson River, the June peak relates to orders from irrigators to supply water mainly for winter cereal or fodder crops while the September peak relates to irrigators "wetting up" cotton fields prior to planting. These farmers then irrigate the fields through summer. While Nathan Dam will not increase water supply for irrigation, the affects of irrigation continue to be reflected within the modelled "With Dam" scenario.

28.5.4. Flow regime change

28.5.4.1. Overview

Before Nathan Dam

Currently under the Full Entitlements scenario, i.e. without Nathan Dam, the modelled flow duration curves show that the flow regime is highly impacted by existing development and flow regulation. The most upstream reporting station, Nathan Gorge shows that low flows have been impacted, and that the river regularly experiences periods of no flow in the Full Entitlement scenario (Figure 28-29 – Graph (A)). In the Pre-development scenario the river is expected to flow 94% of the time, while in the Full Entitlements scenario it is expected to flow 52% of the time.



LEGEND

- Town
- EFO Node
- Additional Flow Statistics Locations
- Weir Locations
- Proposed Pipeline
- Major Watercourses
- Full Supply Level (183.5m AHD)
- Fitzroy Basin
- Catchment Boundaries

Projection: GDA94

Figure 28-29

0 10 20 40
Kilometres

N

Scale 1:2,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Flow duration characterisation downstream of Nathan Dam (No Dam Scenario)

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Within the regulated reach between Orange Creek Weir and Theodore Weir, the Isla Delusion and Southend flow duration curves show elevated low flows (>1 m but <10 cm) and subsequent reduction in impact on zero flows under the Full Entitlements scenario, reflecting releases made for entitlement holders in this reach. The smoother duration curve present at Southend also reflects inflows from small tributaries.

Downstream of Theodore Weir all flows, with the exception of infrequent high flow events, have been reduced in the Full Entitlement scenario, as shown in Figure 28-29.

At Beckers (Figure 28-29– Graph (E)), the impact of flow regulation can be seen on low flows which are artificially maintained, while in the Pre-development scenario, flows are only present for 86 % of the simulation period.

Also evident in Figure 28-29 – Graph (E) is the stepped and uneven nature of flow (caused by operation of the various weirs and extraction by entitlement holders) observed in the flow duration curves. This trend is reflected in flow duration curves for Isla Delusion, Theodore and Beckers (Figure 28-29 – Graph (E)).

Downstream of Beckers (End of Dawson Figure 28-29 – Graph (F-G)), this stepped and uneven nature of flow is no longer present, with the pattern of flow observed to be similar between the Full Entitlement and Pre-development scenario. This is largely due to inflows from the Don River which has a relatively undeveloped catchment.

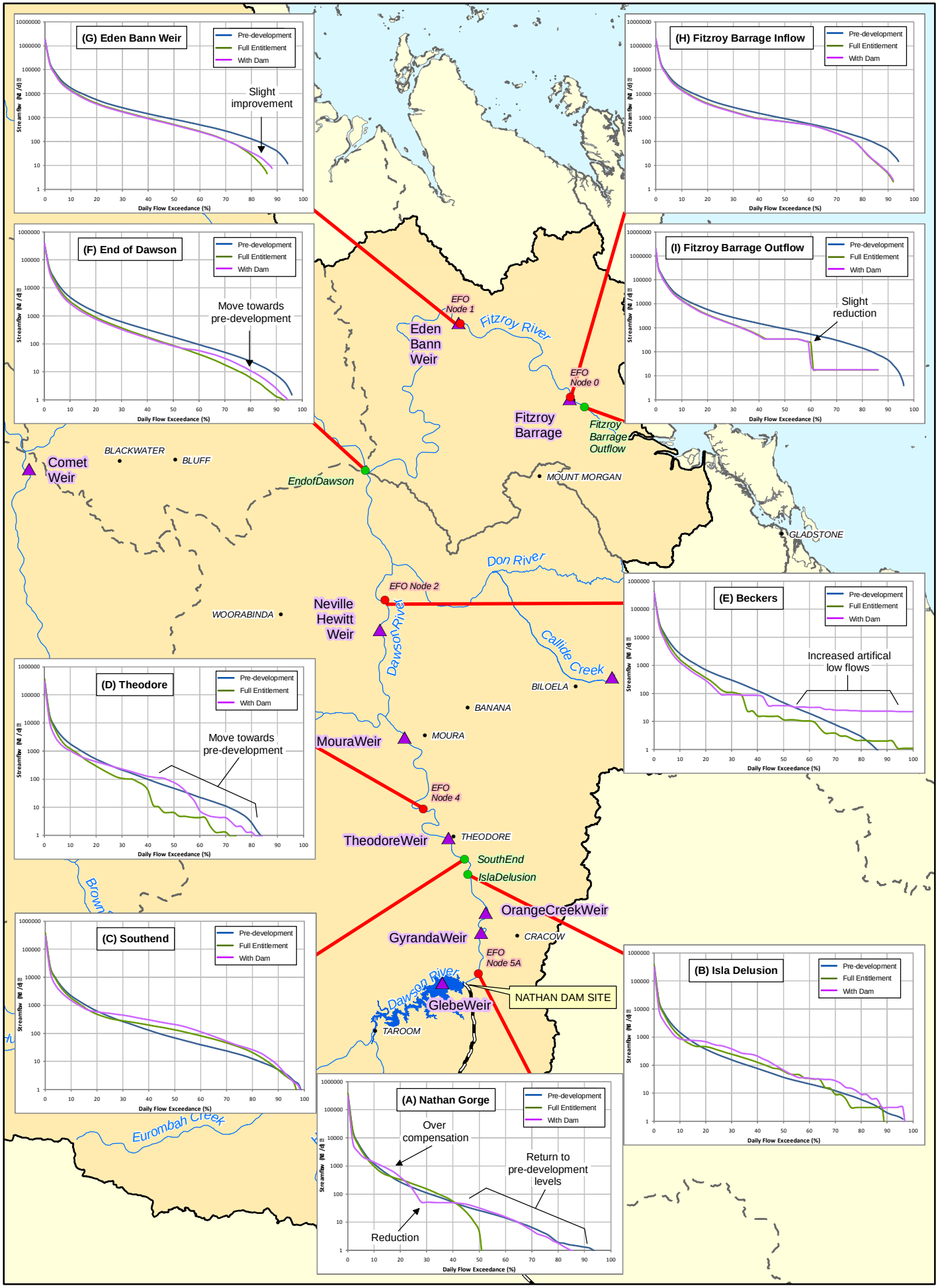
With Dam

The "With Dam" modelled flow duration curves (Figure 28-30) show that, with the exception of the regulate reach between Orange Creek Weir and Theodore Weir, directly downstream of the dam at Nathan Gorge, and at the majority of downstream locations on the Dawson River in the 'With Dam' scenario, the flow regime will more closely simulate natural flows for low flow periods than the Full Entitlements scenario. This is reflected in the 'With Dam' (pink line) being closer to the Pre-development (blue line) than Full Entitlements (green line) is to Pre-development.

Immediately below the dam, low to medium flows, in the 50 to 200 ML/d range, are moderately impacted in the 'With Dam' scenario at Nathan Gorge. Within the regulated reach between Orange Creek Weir and Theodore Weir, low flows are elevated above both Pre-development and Full Entitlements scenarios. Periods of zero flow are more closely reflected under the With Dam scenario. This elevation is associated with releases made for entitlement holders within this reach as well as increased water demand for new users downstream and the natural narrowing of the river channel through this reach of the river. The smoother duration curve present at Southend also reflects inflows from small tributaries.

Below Theodore Weir, low to medium flows, in the 50 to 200 ML/d range are substantially increased downstream of Theodore, primarily due to the seasonal baseflow release and releases to Moura Weir from Theodore Weir.

Medium to high flows, in the 1,500 to 30,000 ML/d range, are moderately impacted in the 'With Dam' scenario. (This range generally covers flushing flows through to half bankfull flows in this reach.) This is particularly evident at Nathan Gorge as these flows are generally captured by the dam; however, these impacts decrease at downstream locations.



LEGEND

- Town
- EFO Node
- Additional Flow Statistics Locations
- Weir Locations
- Proposed Pipeline
- Major Watercourses
- Full Supply Level (183.5m AHD)
- Fitzroy Basin
- Catchment Boundaries

Projection: GDA94

Figure 28-30

0 10 20 40 Kilometres

N

Scale 1:2,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Flow duration characterisation downstream of Nathan Dam (With Dam Scenario)

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Flows above 30,000 ML/d usually occur as part of flooding events, when the dam can receive enough inflow to fill. The larger flows therefore pass through the storage with minimal loss of volume.

By the end of the Dawson River (Figure 28-30) the flow regime has moved closer to pre-development conditions in the 54-94%ile flow range, although a slight decrease is evident in the mid to high range. This move back towards Pre-development is primarily due to inflows from the Don River catchment. The modelled impacts of the dam on flows in the Lower Fitzroy River are minor, mainly due to inflows from the larger Nogoa-Mackenzie catchment.

All of these statistics reflect a move towards a more regulate river reach with more medium flows captured and stored and greater low flow releases.

28.5.4.2. GBR

At the estuary, small flushing flows have been defined as flows equivalent to 211,455 ML/day. Within the 96 year simulation period, these flushing flow events occur less than 5% of the time under Pre-development conditions.

Under the current Full Entitlements scenario, the flow duration curves representing the freshwater flows into the estuary from the Fitzroy River are also shown in Figure 28-30. The flow duration curves presented reflect moderate levels of impact, although a high degree of regulation is evident in the low flow range at Eden Bann Weir and at the end of the Fitzroy River. This is primarily due to the extractions from the water storages (including for Rockhampton city) and the influence of local water harvesters.

Figure 28-31 shows a significant step in the flow duration curve calculated at the end of the Fitzroy River due to the influence of the Barrage fish ladder operations. The fish ladder is operational when the storage volume is greater than 73122 ML, releasing 18 ML/d down the fish ladder. This creates the flat tail of the flow duration curve. Under the current preliminary operations strategy for the dam, there will be minimal change to flow conditions when compared to the current Full Entitlements scenario.

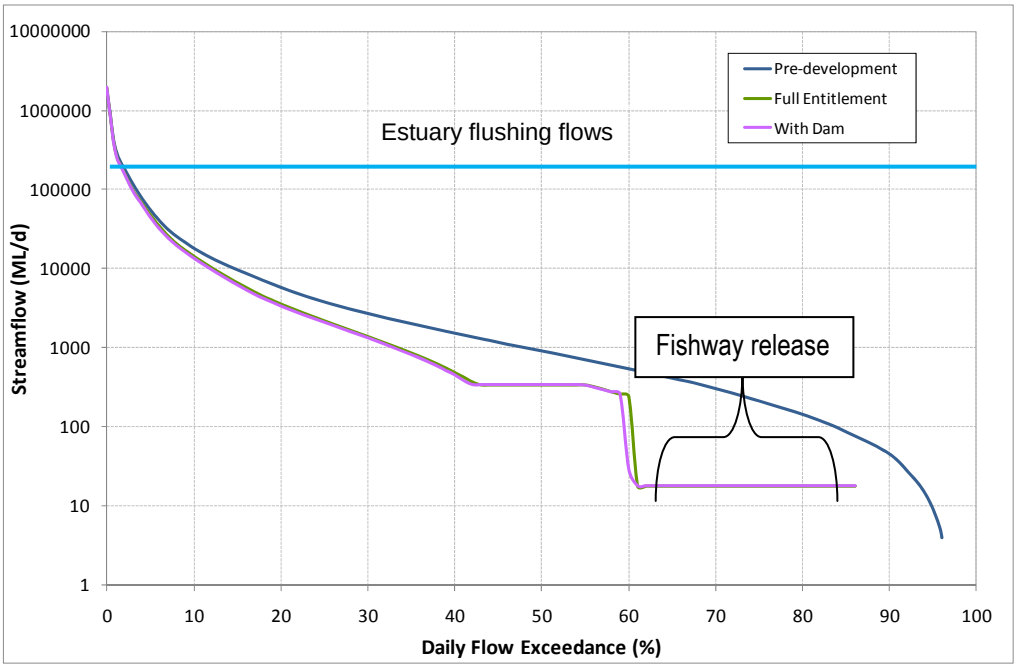
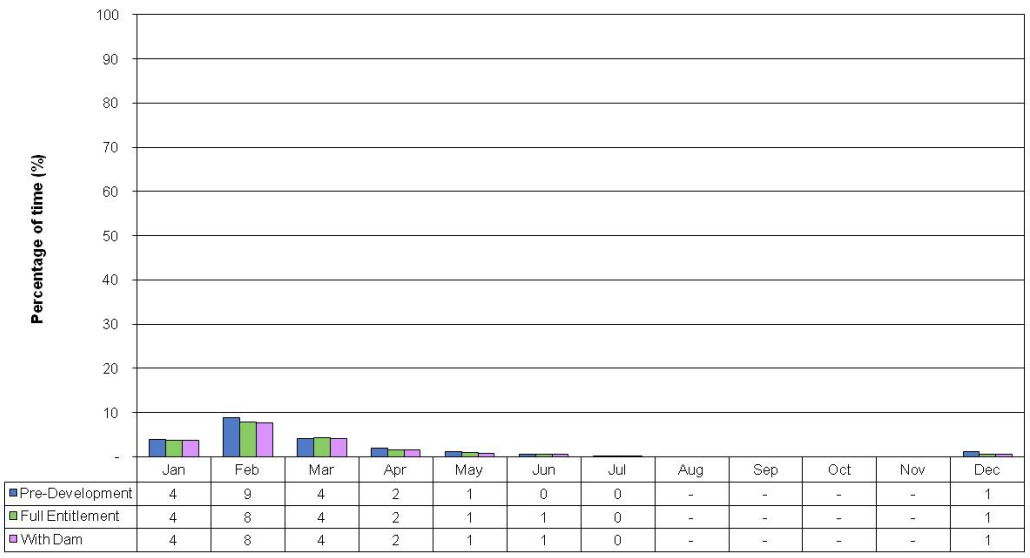


Figure 28-31 Fitzroy Barrage outflow: daily flow volume exceedance

Seasonality of these flushing flows is maintained when compared to the current Full Entitlements scenario (Figure 28-32). Similarly the spells analysis also indicates that there will be little change to these estuary flows (Table 28-36).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	4	9	4	2	1	0	0	-	-	-	-	1
Full Entitlement	4	8	4	2	1	1	0	-	-	-	-	1
With Dam	4	8	4	2	1	1	0	-	-	-	-	1

Figure 28-32 Fitzroy Barrage outflow: monthly frequency analysis

Table 28-36 Estuary flushing flows (2yr ARI) spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	75	65	63
Mean Spell duration (days)	8	9	9
Mean Spell interval (days)	453	523	539

28.5.4.3. Boggomoss Snail

Two riparian flow statistics have been chosen to assess potential flow related impacts on the Boggomoss snail, these include the halfbank and bankfull flows. These statistics have been assessed at two locations on the Dawson River, Isla Delusion and Southend, where Boggomoss snails have been found.

The relationship between riparian vegetation and river flows varies depending on a range of factors including bank profile, soil type, flow conditions, groundwater, rainfall and vegetation composition. The frequency of bankfull flows, as is demonstrated in later sections, highlights that riparian vegetation at or above bankfull mark, is not likely to be solely reliant on river flows for its survival. Occurring on average, once every 1.8 years or every 20 months in Pre-development conditions: riparian vegetation is more likely to be supported by a combination of water sources including groundwater (sometimes elevated via the water stored in nearby weir pools) and rainfall events.

Put into context of the 96 year model simulation period, bankfull flows at the Isla Delusion location are expected to occur just 0.7% of the time with the longest time between these events being up to 9 years under Pre-development conditions (i.e. with no water infrastructure at all). The latter intervals represent droughts.

Current storages on the Dawson River are relatively small and as such have limited capacity to significantly impact higher flows such as the halfbank and bankfull flows (Figure 28-33). As such, current riparian vegetation downstream of the dam has experienced little change with respect to these flows as a result of regulation (Figure 28-33).

With the dam in place, riparian flows downstream of the dam will experience a reduction in these medium to high flows.

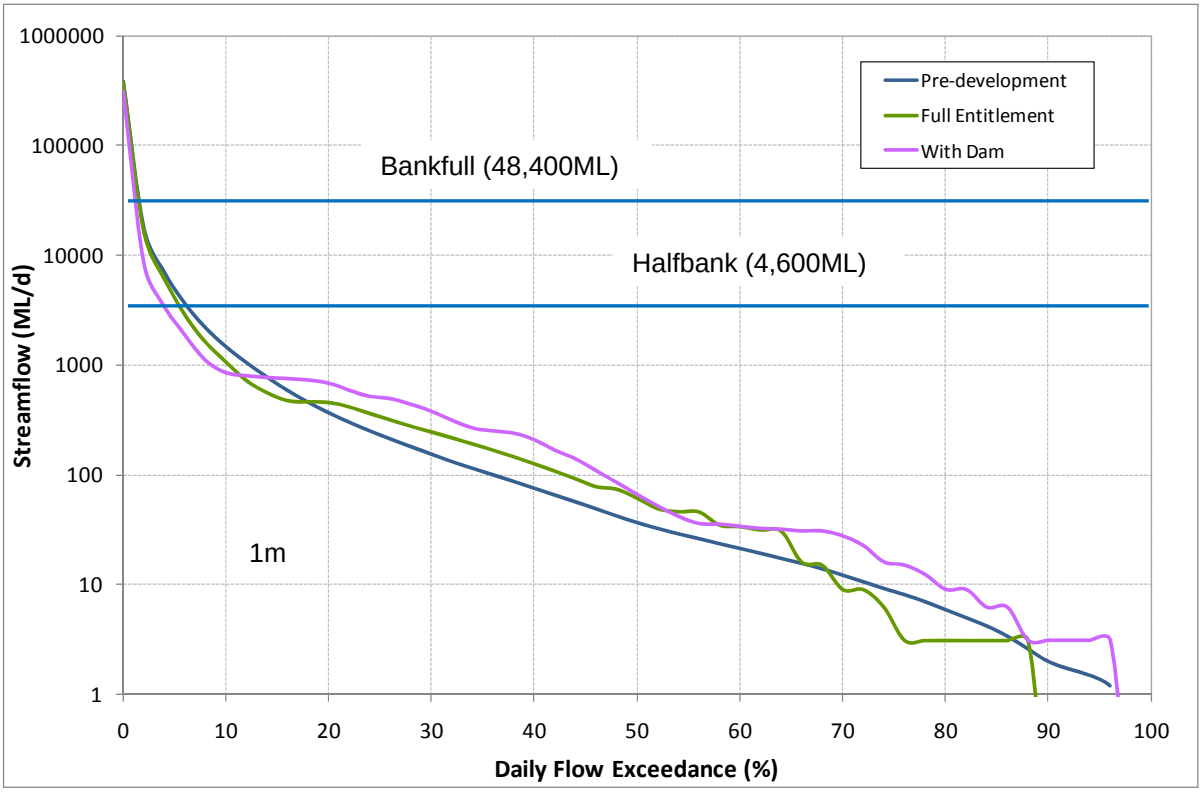
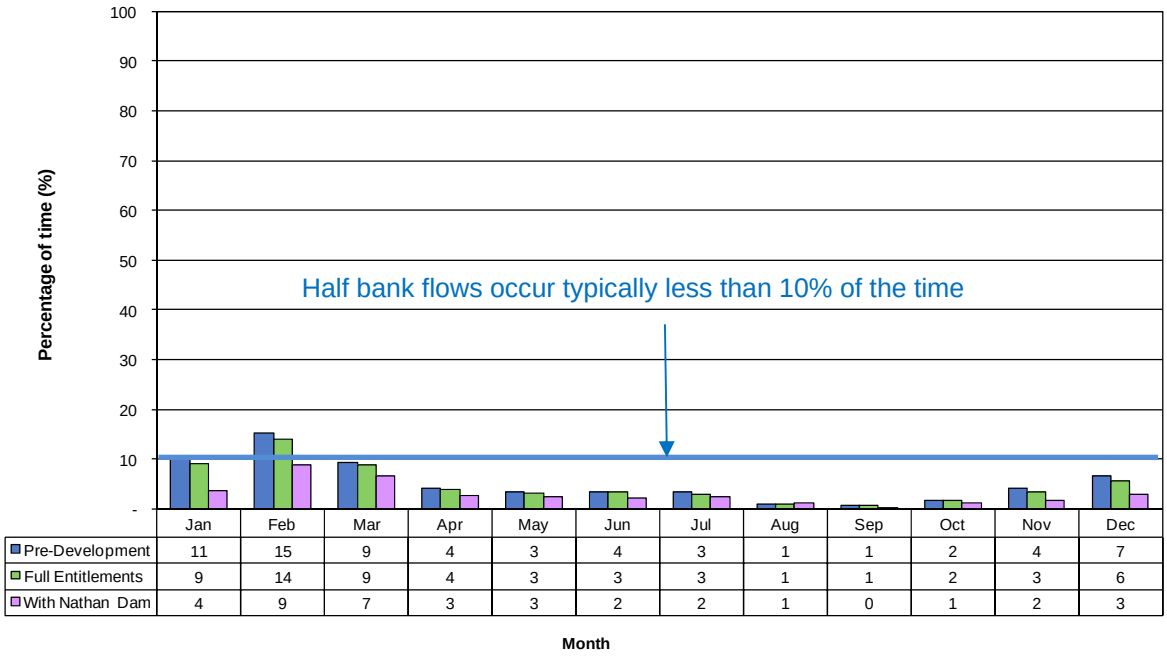


Figure 28-33 Isla Delusion: daily flow volume exceedance

Although there are no known seasonal flow requirements associated with the Boggomoss snail, seasonality of the two key flow indicators has been provided for both Isla Delusion and Southend. At Isla Delusion, Figure 28-34 shows that the seasonality of half bank flows is maintained although there are marginal decreases across all months except August, where no change is noted.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	11	15	9	4	3	4	3	1	1	2	4	7
Full Entitlements	9	14	9	4	3	3	3	1	1	2	3	6
With Nathan Dam	4	9	7	3	3	2	2	1	0	1	2	3

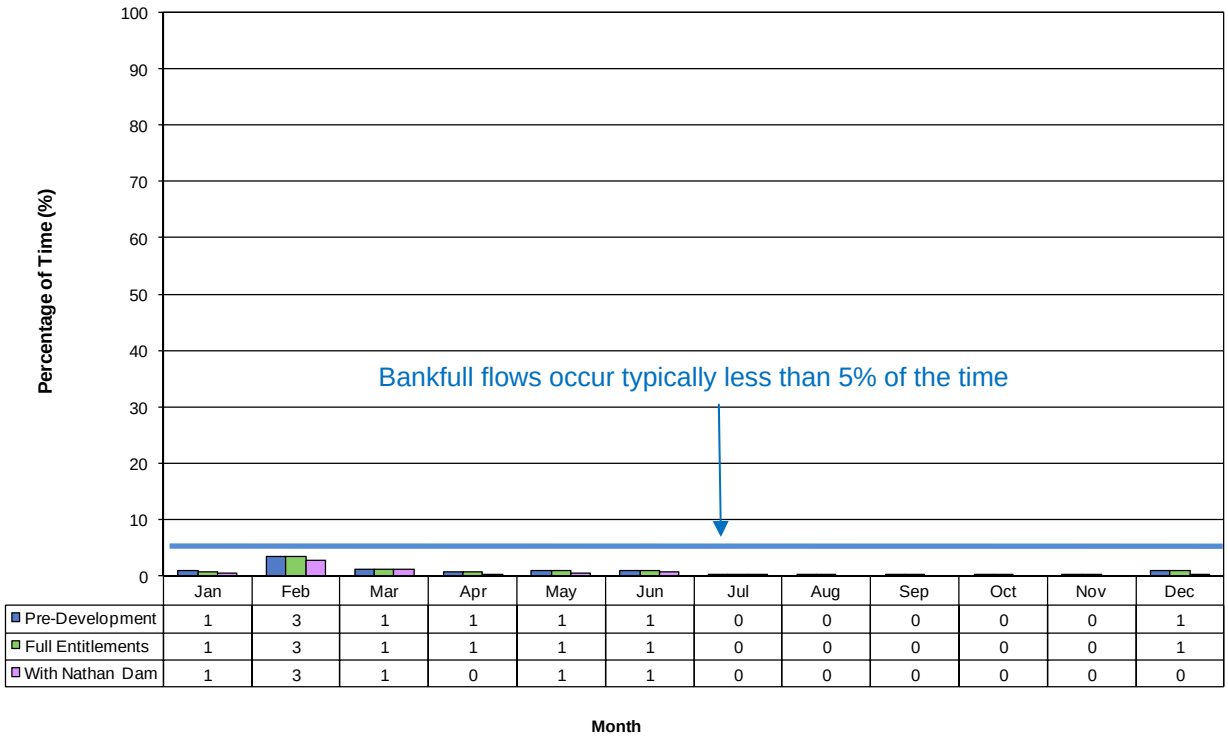
Figure 28-34 Isla Delusion frequency analysis: half bankfull flows (4,600ML/day)

This trend is reflected in the spells analysis (Table 28-37) which shows a reduction in the number of events and associated increase in the time between half bank events from 5 months to 9 months. It should also be noted that the half bank flows under the 'With Dam' scenario will last slightly longer as these flows are generally attenuated as they pass through the dam, reducing the peak volume and extending the duration of the event.

Table 28-37 Isla Delusion half bank spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	226	202	100
Mean Spell duration (days)	8	8	10
Mean spells intervals (months)	4	5	9

Occurring less than three percent of the time in any one month, the seasonality of the bankfull flows is also maintained following construction of Nathan Dam (Figure 28-34). Including flows equal to or greater than 48,400 ML/day, Figure 28-35 highlights that with the dam in place, large flood flows will continue. The degree of flooding however will be tempered by managing flow release during these events, such that the peak is reduced. Reducing the peak of the flood (or the maximum extent of flooding) extends the duration of the event, in this instance from an average from 5 days to 7 days (Table 28-38). It also reduces the number of events (Table 28-38) that are likely to meet the trigger value for the bankfull flow statistic. Whilst the same volume of water may pass by the dam, the managed approach to flow releases means that these flows may pass by at a lower level, reflecting the role of dams in downstream flood mitigation.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	1	3	1	1	1	1	0	0	0	0	0	1
Full Entitlements	1	3	1	1	1	1	0	0	0	0	0	1
With Nathan Dam	1	3	1	0	1	1	0	0	0	0	0	0

Figure 28-35 Isla Delusion frequency analysis: bankfull flows

Table 28-38 Isla Delusion bankfull spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	53	52	25
Mean Spell duration (days)	5	5	7
Mean spells intervals (years)	1.8	1.8	3.7

In assessing the significance of changes to bankfull flows from an average of one event every 1.8 years to one event every 3.7 years, consideration was given to the longest period of time, under pre-development conditions, between bankfull flow events. This duration has been modelled to be an interval of 9 years, reflecting that this riparian vegetation is likely to depend more significantly on groundwater and rainfall, of which the dam will have no negative effect.

Changes associated with the dam on riparian vegetation downstream are therefore considered not to be significant for the Boggomoss snail.

A short distance downstream at the Southend reach of the Dawson River, high flow conditions are less impacted, reflecting local stream inputs and a narrowing of the channel (Figure 28-36). Modelling predicts that there will be an increase in the frequency of low flows between 10 cm and 1 m.

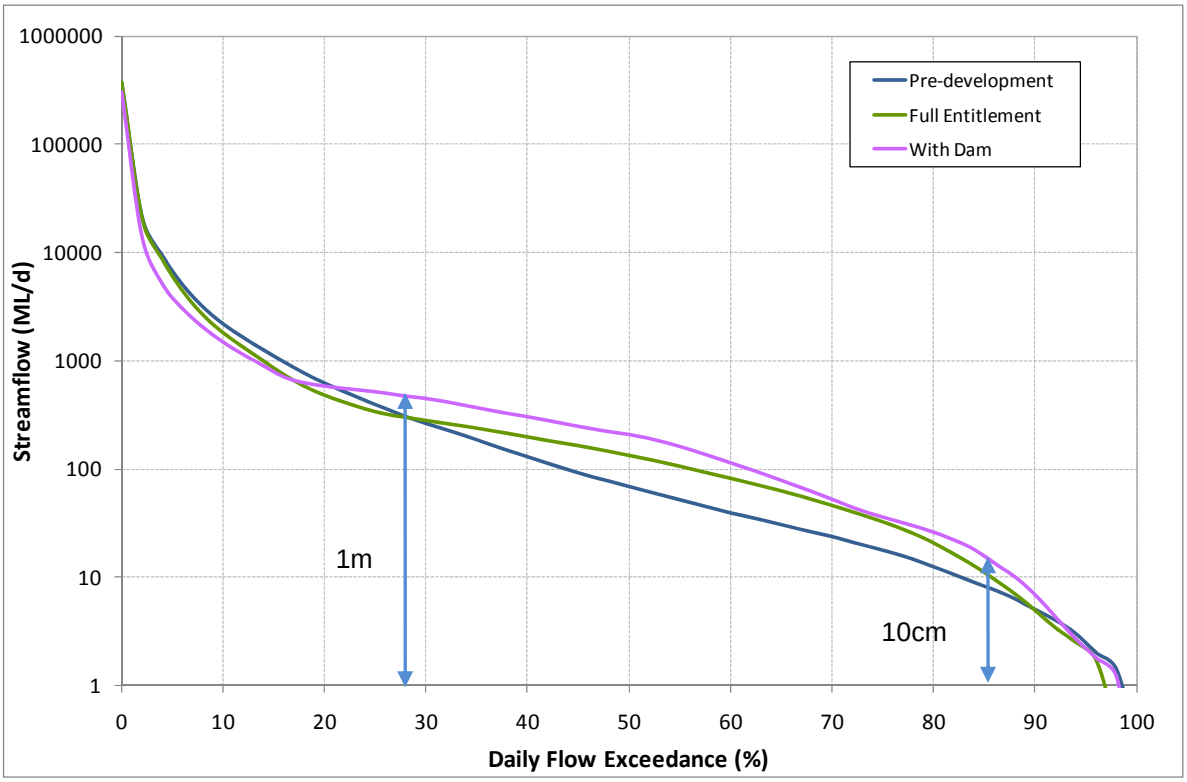
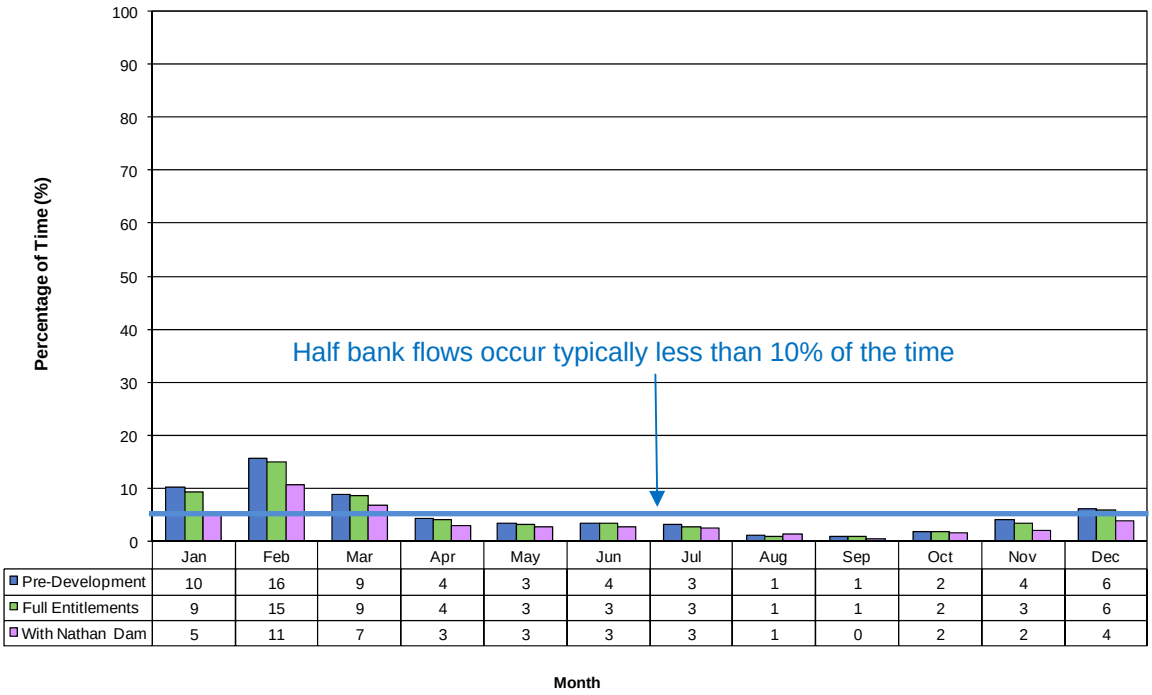


Figure 28-36 Southend: daily flow volume exceedance

Seasonality of these medium to high flows is maintained with a small change to the number and time between events. Unlike Isla Delusion, there is no change to the duration of bankfull flows at this location. This is reflective of local inflows from Gorge Creek and the bank profile at this location being narrower at top of bank.



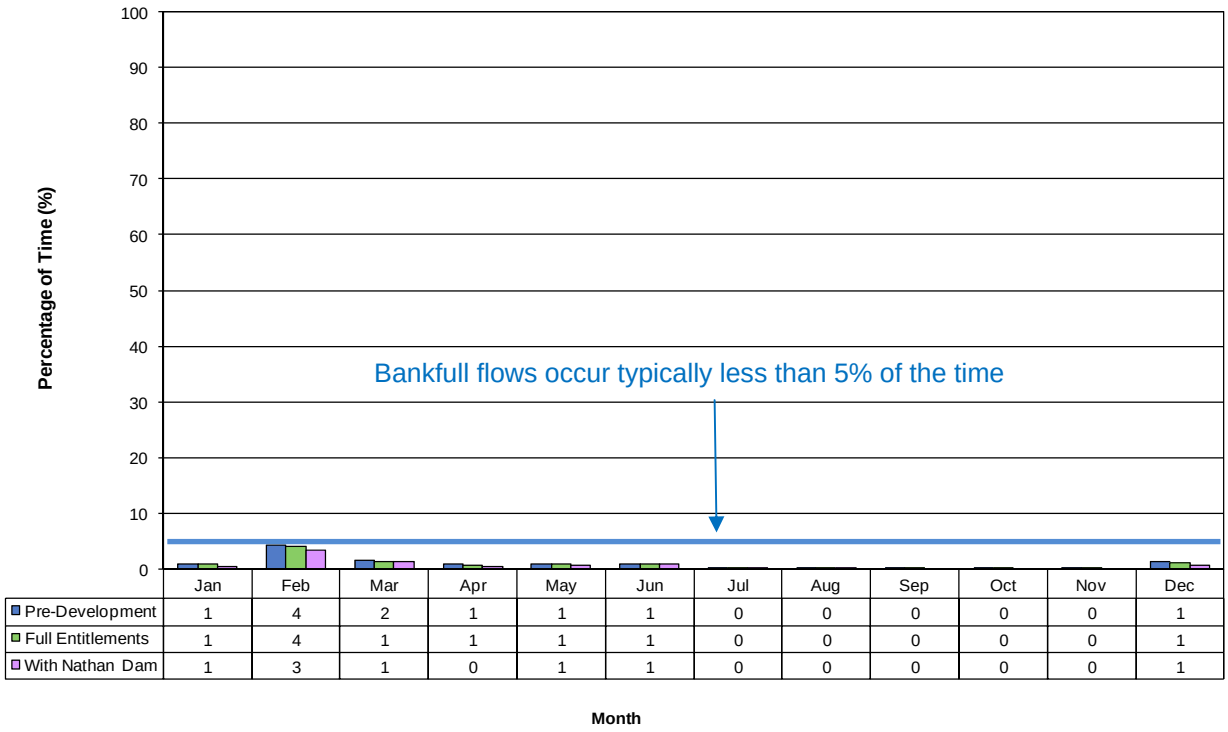
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	10	16	9	4	3	4	3	1	1	2	4	6
Full Entitlements	9	15	9	4	3	3	3	1	1	2	3	6
With Nathan Dam	5	11	7	3	3	3	3	1	0	2	2	4

Figure 28-37 Southend frequency analysis: half bankfull flows

Table 28-39 Southend half bank spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	223	200	159
Mean Spell duration (days)	8	8	8
Mean spells intervals (years)	0.4	0.5	0.6

A similar trend is observed for the bankfull flows with no change to the predicted monthly flows for 10 out of 12 months and minor changes in February and April. Unlike Isla Delusion, the number and time between events has changed to a lesser degree with a minor increase to the duration of events. Again, no significant impacts are expected to occur to riparian vegetation at this location and therefore Boggomoss snail inhabiting this area. The reduction in bankfull and overbank flooding events may also be beneficial in reducing the threat of flooding to the riparian snail populations and thus enhancing the survival of the Dawson River populations.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	1	4	2	1	1	1	0	0	0	0	0	1
Full Entitlements	1	4	1	1	1	1	0	0	0	0	0	1
With Nathan Dam	1	3	1	0	1	1	0	0	0	0	0	1

Figure 28-38 Southend frequency analysis: Bankfull flows

Table 28-40 Soundend Bankfull flow Spells Analysis

	Pre-development	Full Entitlement	With Dam
No. of events	66	62	42
Mean Spell duration (days)	5	5	6
Mean spells intervals (years)	1.4	1.5	2.2

28.5.4.4. Fitzroy River Turtle

To date no live Fitzroy River turtle records have been identified at or above the dam despite several surveys since 2007. Downstream of the dam both the Fitzroy River turtle and their nests have been recorded within and upstream of Theodore Weir. These records constitute the most upstream records of the Fitzroy River turtle on the Dawson River. To determine potential impacts in this reach of the river, the Isla Delusion and Southend cross sections have again been used.

The key ecological statistics for the Fitzroy River turtle are focused around low flows (10 and 30 cm) that maintain riffles and flushing flows to maintain water quality. Seasonal demand for water at the commencement of the growing season in October through to January, along with constant baseflow demands, are clearly identifiable in the 10 and 30 cm flows. It

is also evident that there has been a decrease in some monthly low flow statistics when compared to the Pre-development scenario, reflecting the reduced need for water in the winter months.

With respect to flushing flows, the current Full Entitlements scenario differs little from Pre-development conditions, reflecting the smaller storages inability to capture these types of events.

With the focus on low flows, it is important to remember that the flow duration curves are presented on log scales. As demonstrated in Figure 28-39 and Figure 28-40 small changes in these flows can appear as large steps which in some instances reflect a change of no more than 2-3 cm in depth at that location.

For the chosen Isla Delusion cross section, the impacts of downstream water use is evident in the stepped and uneven nature of the flow duration curve Figure 28-39. As can be seen in Figure 28-40 the majority of these steps or releases represent flows less than 30 cm. Currently the Full Entitlements scenario indicates that the period of flows less than 20 cm has reduced compared to the pre-development case. With Dam, these flows are predicted to further increase with the percentage of zero flows becoming more reflective of pre-development levels.

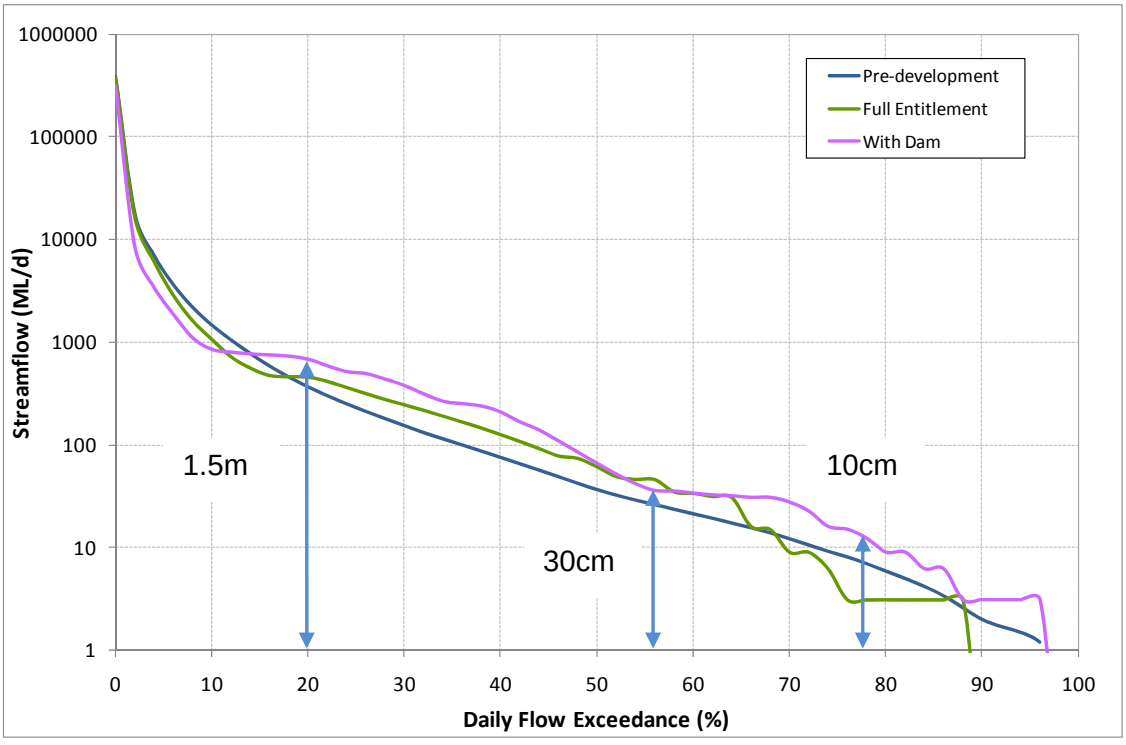
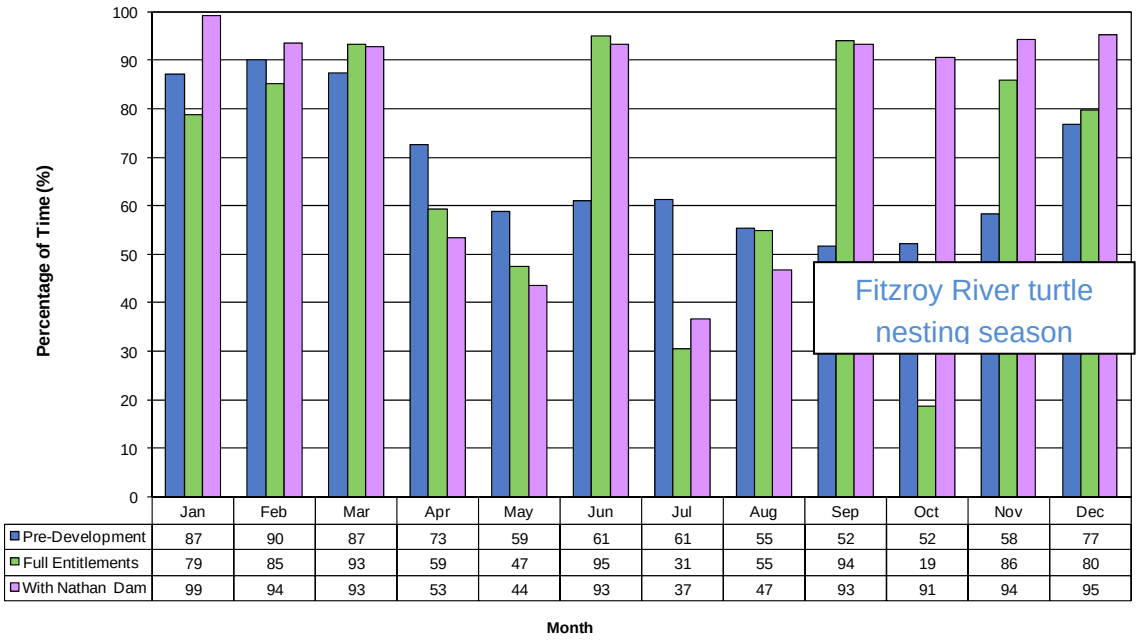


Figure 28-39 Isla Delusion: daily flow volume exceedance

Although no additional water is likely to be available to irrigators downstream, the pattern of increased flows in the months of September to February continues to be evident in the monthly frequency analysis (Figure 28-40). The increase in flows reflects the addition of water for non-agricultural users.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	87	90	87	73	59	61	61	55	52	52	58	77
Full Entitlements	79	85	93	59	47	95	31	55	94	19	86	80
With Nathan Dam	99	94	93	53	44	93	37	47	93	91	94	95

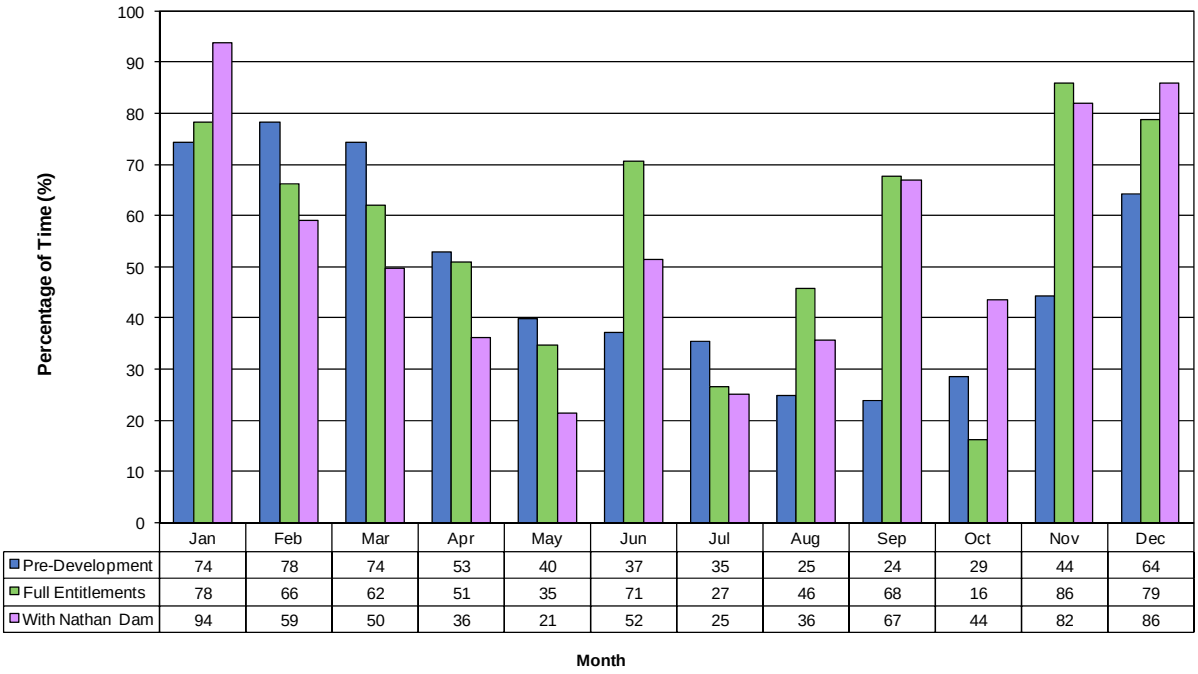
Figure 28-40 Isla Delusion frequency analysis: 10 cm flows or greater

With the increase in 10 cm flows or greater there will be a slight change to the nature of flows downstream to more events, closer together. Rather than occurring on average every 12 days they will occur every 7 days, although they will be slightly shorter in duration Table 28-41. These graphs and tables highlight that frequency of riffle forming flows will most likely increase, compared to Full Entitlements scenario in the months of the turtle nesting season, with this trend continuing in all months except April, May and August where a small reduction in the frequency of 10 cm flows or greater is possible. It is therefore concluded that the low flow regime post dam will not significantly impact the ecology of the existing Fitzroy River turtle population at this location as regular flows are maintained. Any impact may in fact be beneficial by maintaining riffles for longer.

Table 28-41 Isla Delusion 10 cm or greater spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	509	904	1083
Mean Spell duration (days)	47	27	25
Mean Spell interval (days)	22	12	7

A similar trend is noted for the 30 cm flows or greater which facilitate movement between pools. Seasonal water demands create good connectivity during the nesting season with slight reductions in autumn and winter.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	74	78	74	53	40	37	35	25	24	29	44	64
Full Entitlements	78	66	62	51	35	71	27	46	68	16	86	79
With Nathan Dam	94	59	50	36	21	52	25	36	67	44	82	86

Figure 28-41 Isla Delusion frequency analysis: 30cm flows or greater

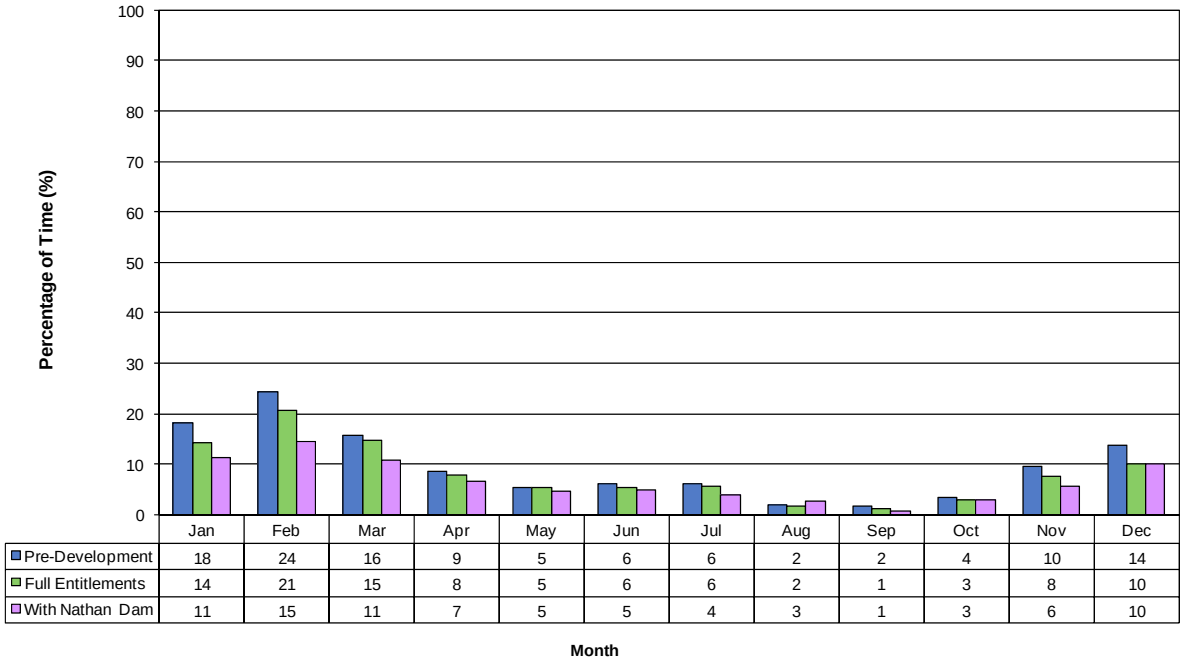
Again with the increase in frequency of 30 cm or greater flows will come a slight change in how flows are released downstream. With significantly more events, 30 cm flows or greater will on average occur 9 days apart rather than the currently modelled 11 days and will be slightly shorter in duration (Table 28-42).

Table 28-42 Isla Delusion 30 cm or greater spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	408	1483	2433
Mean Spell duration (days)	42	13	8
Mean Spell interval (days)	34	11	9

It is not anticipated that the dam will significantly impact the existing Fitzroy River turtles living at or near this location.

Figure 28-42 highlights that the seasonality of flushing flows (1,600 ML/day) will continue with the dam. There will be fewer events however flushing will occur over a slightly longer period as controlled releases are made (Table 28-43).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	18	24	16	9	5	6	6	2	2	4	10	14
Full Entitlements	14	21	15	8	5	6	6	2	1	3	8	10
With Nathan Dam	11	15	11	7	5	5	4	3	1	3	6	10

Figure 28-42 Isla Delusion frequency analysis: flushing flows 1,600 ML/day or greater

Relative to Full Entitlement conditions, it is not anticipated that these changes will significantly alter conditions downstream for the Fitzroy River turtle particularly when considered in the context of the Southend modelling results.

Table 28-43 Isla Delusion flushing flows or greater spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	315	259	180
Mean Spell duration (days)	11	11	13
Mean Spell interval (days)	100	124	181

Figure 28-43 shows that within 10 km of the Isla Delusion cross section, the affects of downstream releases has been reduced by small inflows into the Dawson River (change from a stepped to smooth flow duration curve).

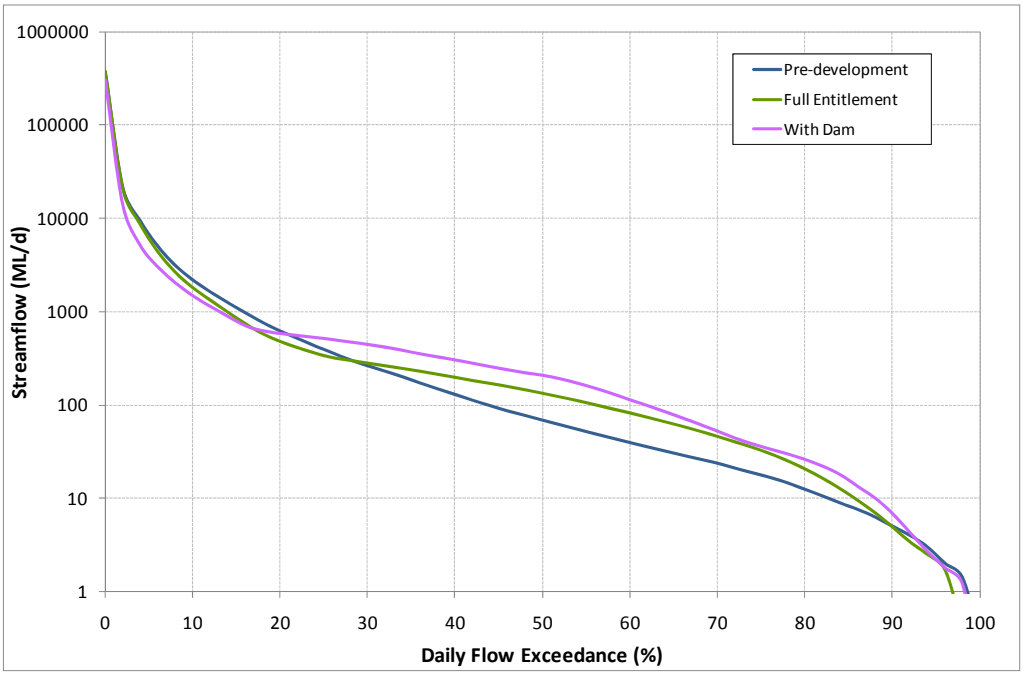
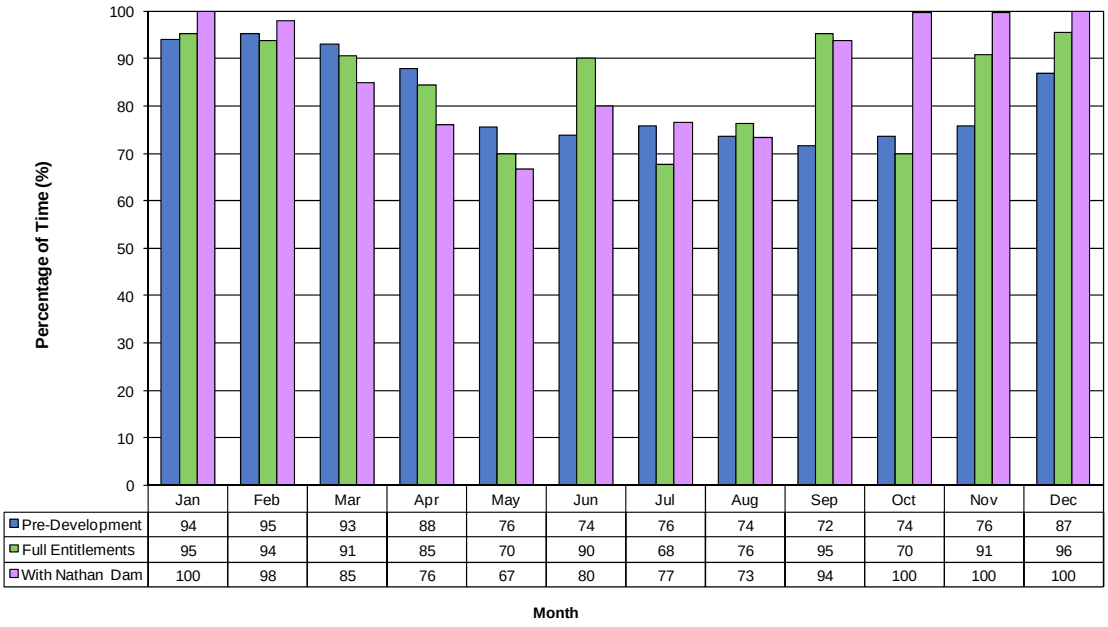


Figure 28-43 Southend: daily flow volume exceedance

Similar to the Isla Delusion location, seasonal water demands in September to February provide more constant baseflows (Figure 28-44).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	94	95	93	88	76	74	76	74	72	74	76	87
Full Entitlements	95	94	91	85	70	90	68	76	95	70	91	96
With Nathan Dam	100	98	85	76	67	80	77	73	94	100	100	100

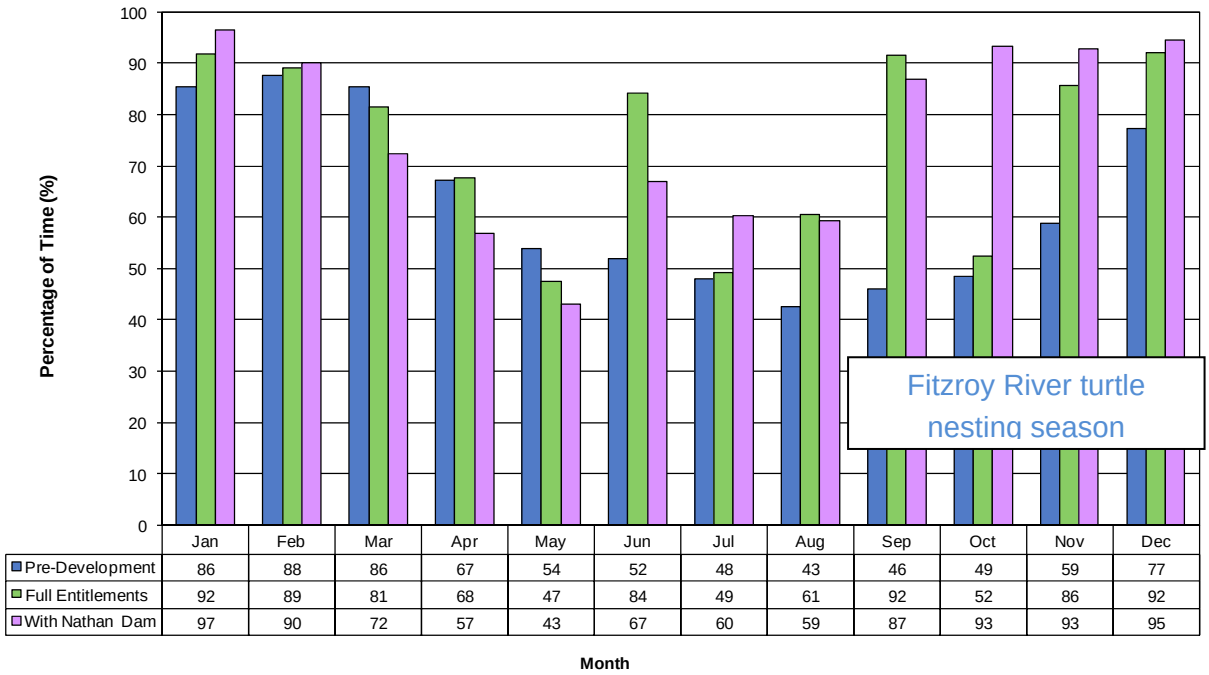
Figure 28-44 Southend frequency analysis: 10 cm flows or greater

The spells analysis indicates that whilst there will be fewer events this is because they have merged together to create longer events (73 days compared to 57 days) at roughly the same spell interval (Table 28-44).

Table 28-44 Southend 10 cm or greater spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	482	520	417
Mean Spell duration (days)	59	57	73
Mean Spell interval (days)	14	10	11

Compared to the existing conditions under the Full Entitlements scenario, With Dam there are few significant changes to the 30cm flows or greater with connectivity likely to be maintained or enhanced during and leading up to the nesting season (Figure 28-45).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	86	88	86	67	54	52	48	43	46	49	59	77
Full Entitlements	92	89	81	68	47	84	49	61	92	52	86	92
With Nathan Dam	97	90	72	57	43	67	60	59	87	93	93	95

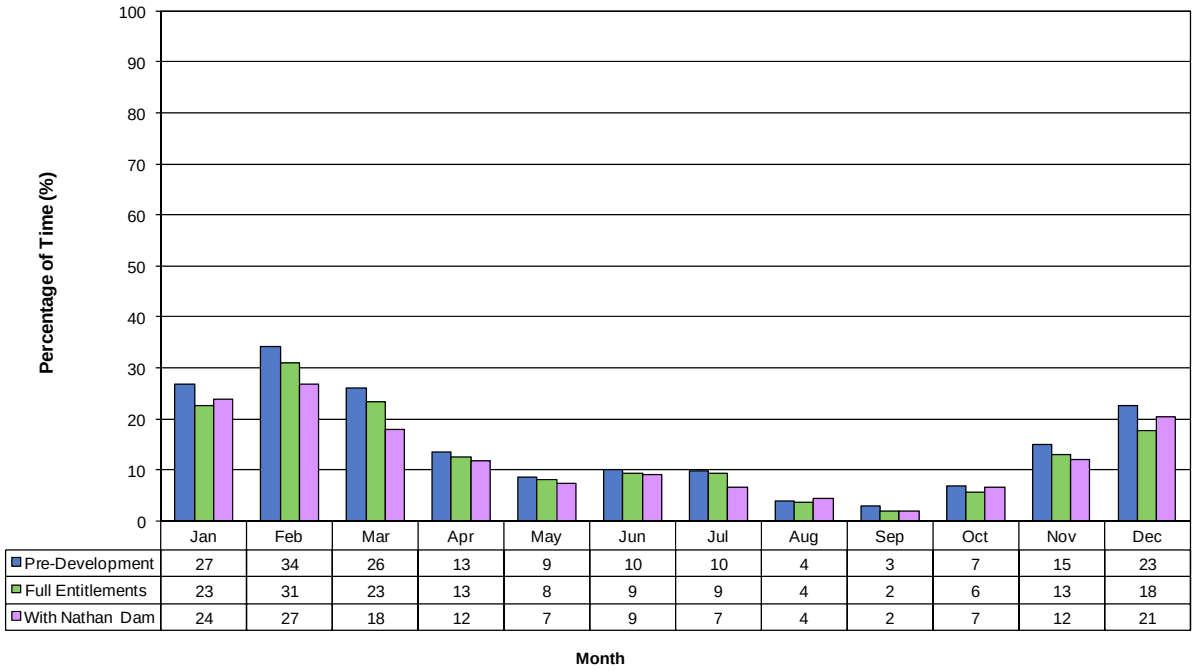
Figure 28-45 Southend frequency analysis: 30 cm flows or greater

Like the 10 cm flows, the spells analysis indicates that whilst there will be fewer events this is because they have merged together to create longer events (44 days compared to 33 days) (Table 28-45). Unlike 10 cm flows however they will occur slightly closer together compared to the current Full Entitlements scenario.

Table 28-45 Southend 30 cm or greater spells analysis

	Pre-development	Full Entitlement	With Dam
No. of events	741	792	609
Mean Spell duration (days)	30	33	44
Mean Spell interval (days)	18	11	14

Figure 28-46 highlights that the seasonality of flushing flows (1,100 ML/day) will be maintained with little or no change over the 12 month modelling period.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	27	34	26	13	9	10	10	4	3	7	15	23
Full Entitlements	23	31	23	13	8	9	9	4	2	6	13	18
With Nathan Dam	24	27	18	12	7	9	7	4	2	7	12	21

Figure 28-46 Southend frequency analysis: flushing flows 1,100 ML/day or greater

Unlike the Isla Delusion location, Southend can expect on average to experience more (443 compared to 403) flushing events of slightly lower duration compared to the current Full Entitlements scenario (Table 28-46).

Table 28-46 Southend Flushing flows or greater Spells Analysis

	Pre-development	Full Entitlement	With Dam
No. of events	429	403	443
Mean Spell duration (days)	12	12	10
Mean Spell interval (days)	85	94	95

In summary, the Fitzroy River turtle is currently living and nesting in a reach in which low flows are highly regulated and medium to larger flows have been maintained. With the operation of the dam, it is anticipated that conditions will largely remain the same with some increases in riffle forming flows and improved connectivity during the nesting season. Further the seasonality of flushing flows is predicted to remain relatively unchanged.

28.5.5. Cumulative

In assessing potential changes to flow conditions downstream of the dam, the hydrologic model takes into account the operating conditions of existing water infrastructure such as Gyranda and Theodore Weirs. As such, the cumulative impacts of existing water infrastructure are inherently built into the model and assessed.

With no other proposed water infrastructure projects located on the Dawson River, this section focuses on potential cumulative impacts associated with proposed water infrastructure with the potential to influence flow conditions downstream of the Dawson/Mackenzie River junction (Figure 28-47).

The restricted range of the Boggomoss Snail means that this species is not affected by potential cumulative flow impacts and is therefore not assessed in this section. There are however, known records of Fitzroy River turtles and nesting locations downstream of the Dawson/Mackenzie River junction (Figure 28-18). Further, flows into the GBR will also be affected should these additional water infrastructure projects proceed.

Outlined in section 14.2.4, a Cumulative Impacts scenario was modelled in order to represent the infrastructure currently proposed for the basin: Connors River Dam, Nathan Dam and Lower Fitzroy Weirs. Each of these developments is in the approvals phase and requires a full business case to be developed and approved before they can proceed. It is not assured that they will all progress.

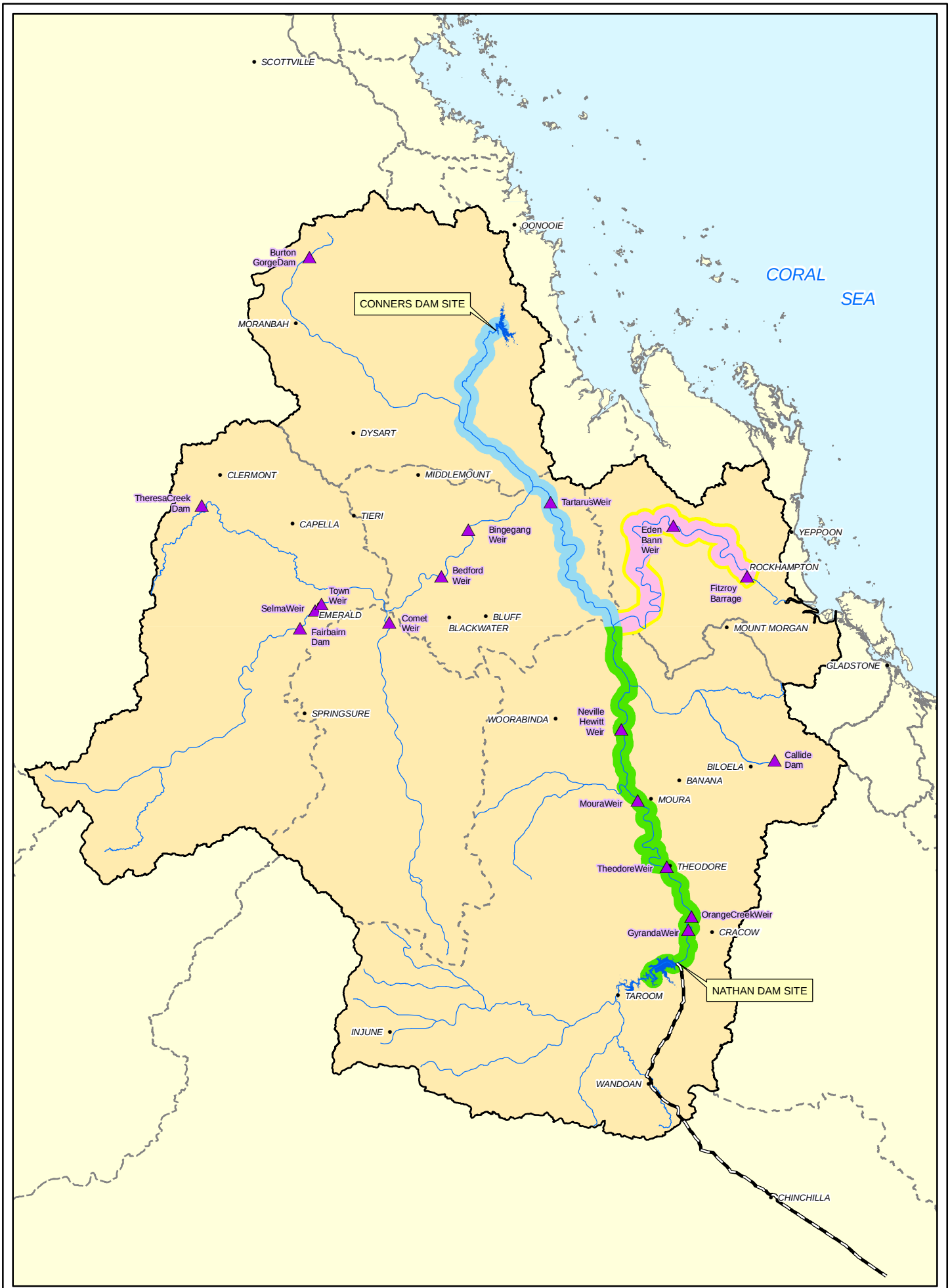
28.5.5.1. GBR

Section 28.5.1 outlined that the flow conditions important to the GBR are the regular small floods which provide flushing of the estuary. At the Fitzroy Barrage outflow reporting location, these minor flood flows were defined as being flows equivalent to 211,455 ML/day.

Figure 28-48 demonstrates that such flows (flows 211,455 ML and above) are largely unchanged under the cumulative impacts scenario. What is likely to change however are the medium to small flows as reflected in the dip in the flow duration curve at this location.

With respect to seasonality of small flushing flood flows into the estuary, Figure 28-49 demonstrates that there is unlikely to be a significant change. Similarly the spells analysis for this location also indicates that there will be little change to these flows (Figure 28-52).

It is worth noting that the WRP statistic for Marine and Estuarine Processes is also compliant under the cumulative impact scenario (Section 14.2.4).



LEGEND

- Town
- Weir Locations
- Proposed Pipeline
- Major Watercourses
- Full Supply Level
- Fitzroy Basin
- Catchment Boundary

Impact Area

- Lower Fitzroy River
- Nathan Dam
- Conners Dam
- Cumulative Impact Zone

Projection: GDA94

Figure 28-47

0 20 40 80
Kilometres

N

Scale 1:3,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Extent of cumulative flow impacts

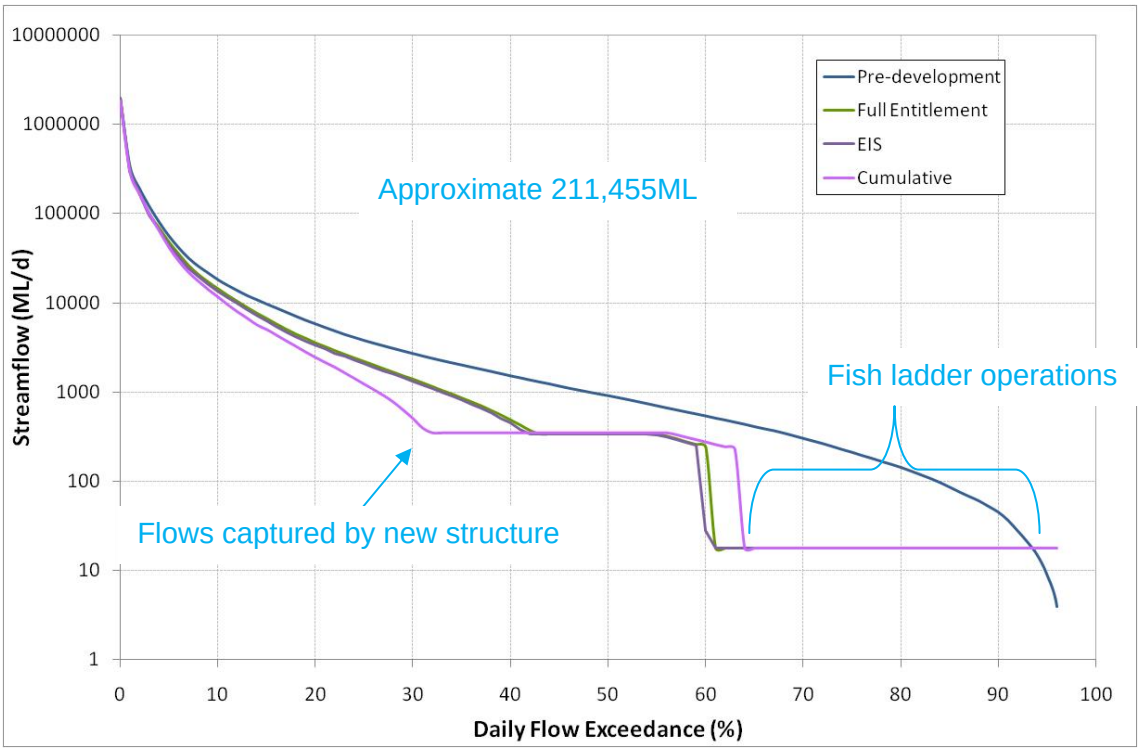
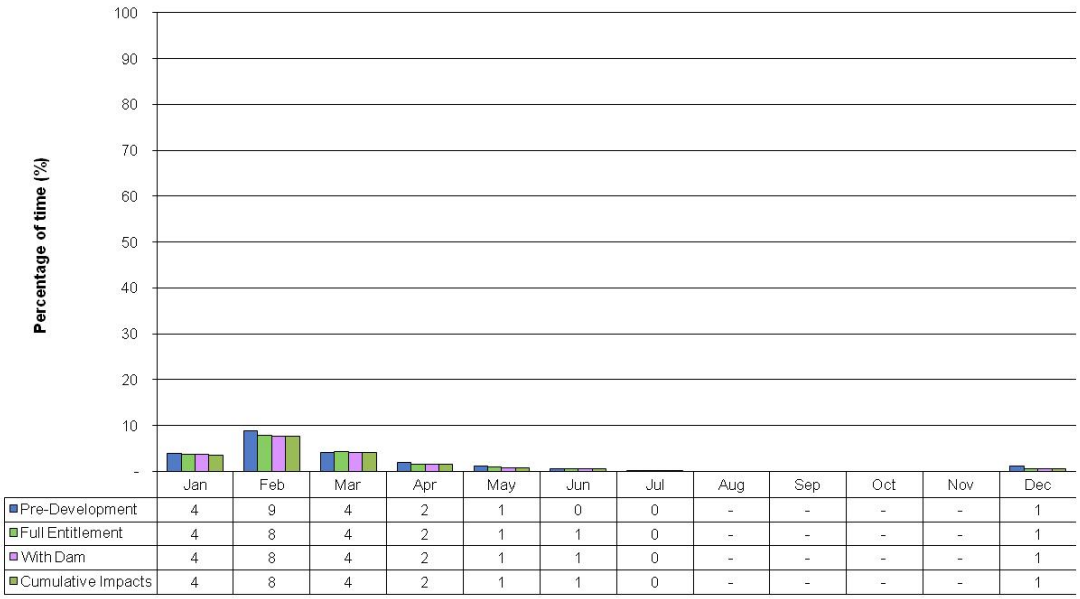


Figure 28-48 Fitzroy Barrage Outflow flow duration curve: Cumulative Impact Scenario



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	4	9	4	2	1	0	0	-	-	-	-	1
Full Entitlement	4	8	4	2	1	1	0	-	-	-	-	1
With Dam	4	8	4	2	1	1	0	-	-	-	-	1
Cumulative Impacts	4	8	4	2	1	1	0	-	-	-	-	1

Figure 28-49 Fitzroy Barrage Outflows Frequency: Estuary Flushing Flows (2yr ARI or greater) Cumulative Impacts Scenario

Table 28-47 Estuary Flushing Flows (2yr ARI or greater) spells analysis

	Pre-development	Full Entitlement	With Dam	Cumulative
No. of events	75	65	63	62
Mean Spell duration (days)	8	9	9	9
Mean Spell interval (days)	453	523	539	548

28.5.5.2. Fitzroy River turtle

For the purpose of the cumulative impact assessment, an additional Fitzroy River cross section was obtained at Wattlebank, located downstream of Eden Bann Weir. This site was selected on the basis that there are Fitzroy River turtle records and nests downstream of this location. Changes to 10 cm, 30 cm and flushing flows were then assessed for the cumulative impacts scenario. All of these statistics reflect a move towards a more regulate river reach with more medium flows captured and stored and greater low flow releases.

Within the Fitzroy River (Figure 28-30) the Full Entitlements and With Dam scenario are largely the same with the flow duration curves overlapping. In the Cumulative Impacts scenario (Figure 28-56), low flow conditions are predicted to increase, deviating above and below Pre-development levels. Conversely, more flows between 1000 ML/d and 10,000 ML/d will be captured within upstream storages. This location is less affected comparatively due to contributing flows from other rivers and its location within a large catchment,

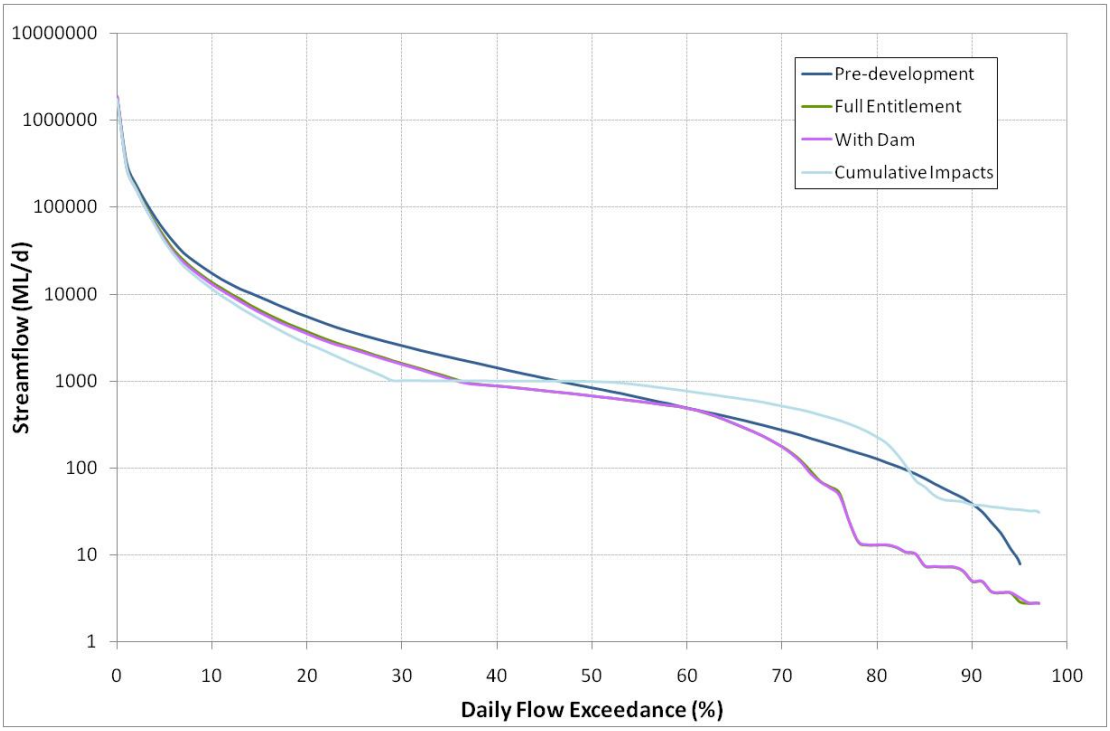
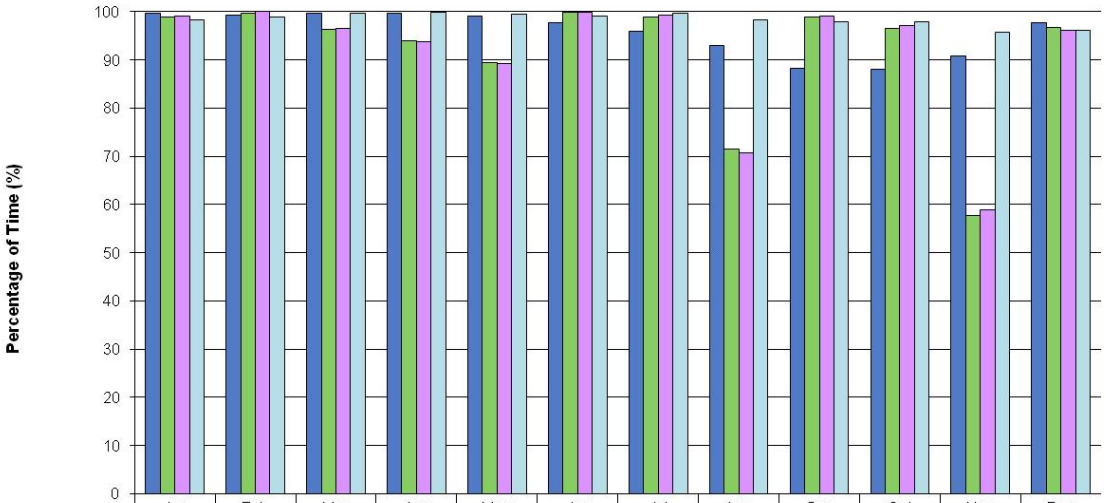


Figure 28-50 Wattlebank: daily flow volume exceedance

Within the 10 cm flow range, the Cumulative Impacts scenario demonstrates an increase in connectivity (riffles/water quality) across the majority of months, with several months, (April, May, August, November) reflecting Pre-development levels Figure 28-51.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	100	99	100	100	99	98	96	93	88	88	91	98
Full Entitlement	99	100	96	94	90	100	99	72	99	97	58	97
With Dam	99	100	97	94	89	100	99	71	99	97	59	96
Cumulative impacts	98	99	100	100	99	99	100	98	98	98	96	96

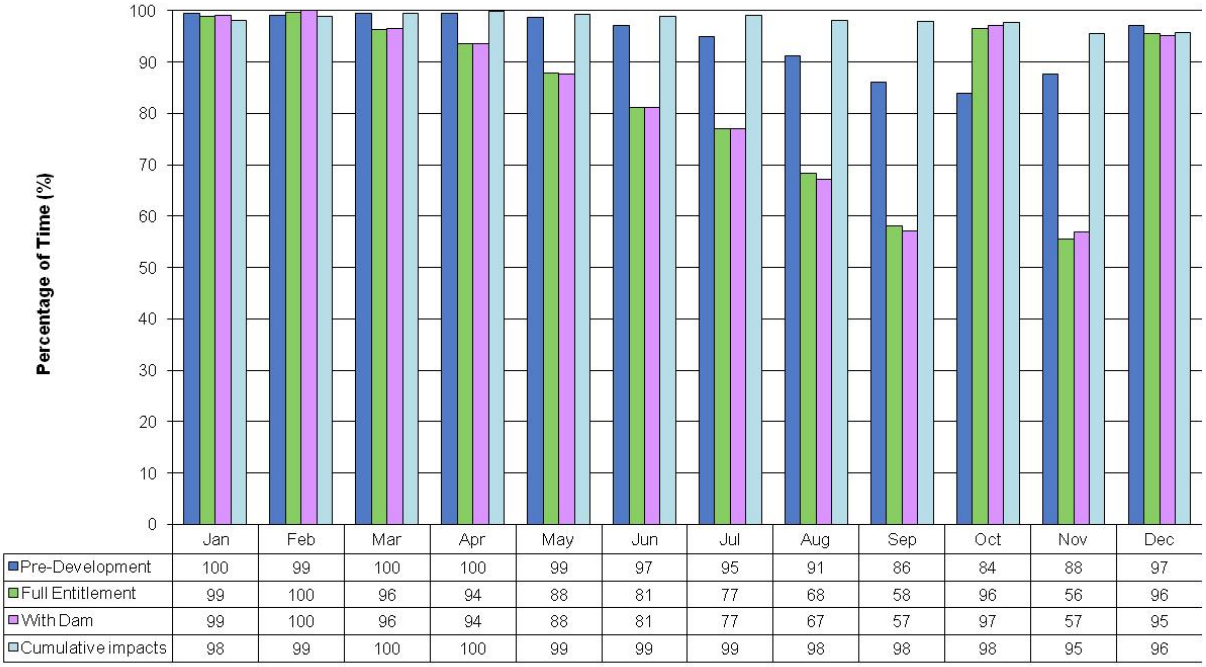
Figure 28-51 Wattlebank frequency analysis: 10 cm flows or greater

The Spells analysis for this section of the Fitzroy River indicates that a number of the 10 cm flow events are combining to form longer flow events (Table 28-48).

Table 28-48 Wattlebank 10 cm or greater Spells analysis

	Pre-development	Full Entitlement	With Dam	Cumulative
No. of events	86	314	336	46
Mean Spell duration (days)	390	102	96	750
Mean Spell interval (days)	18	9	9	12

Within the 30 cm flow range, the Cumulative Impacts scenario demonstrates an increase in connectivity (movement) across several months (March to November) with a strong return to Pre-development seasonality (Figure 28-52).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	100	99	100	100	99	97	95	91	86	84	88	97
Full Entitlement	99	100	96	94	88	81	77	68	58	96	56	96
With Dam	99	100	96	94	88	81	77	67	57	97	57	95
Cumulative impacts	98	99	100	100	99	99	99	98	98	98	95	96

Figure 28-52 Wattlebank frequency analysis: 30 cm flows or greater

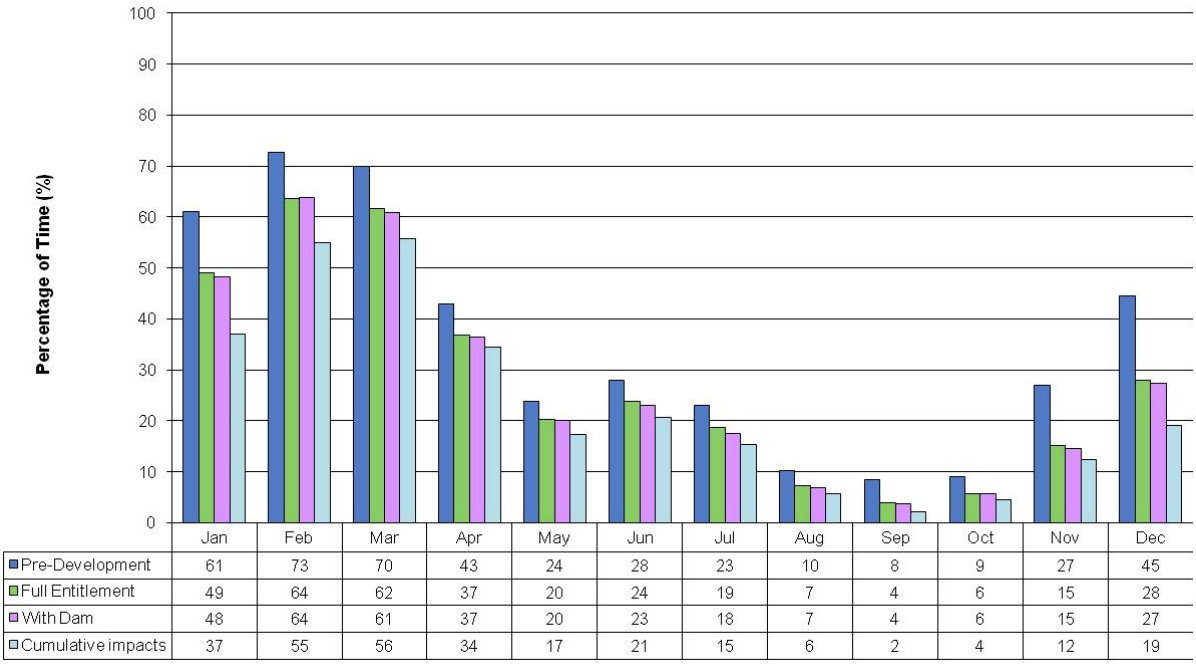
The spells analysis for the 30 cm flow events so the same trend towards many low flow events combining to form longer flow events.

Table 28-49 Wattlebank 30 cm or greater spells analysis.

	Pre-development	Full Entitlement	With Dam	Cumulative
No. of events	98	546	570	69
Mean Spell duration (days)	338	54	52	499
Mean Spell interval (days)	20	10	10	9

Within the flushing flows range the spells analysis reflects a slight reduction in the number of events which are predicted to occur on average an additional 15 days further apart than the With Dam scenario. This change is not expected to significantly impact upon water quality and could be managed during the development of an environmental flow release strategies for the various items of infrastructure.

Between the current Full Entitlements scenario and With Dam, there is very little change across the twelve months. Seasonality is maintained in both the With Dam and Cumulative Impact scenarios.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Development	61	73	70	43	24	28	23	10	8	9	27	45
Full Entitlement	49	64	62	37	20	24	19	7	4	6	15	28
With Dam	48	64	61	37	20	23	18	7	4	6	15	27
Cumulative impacts	37	55	56	34	17	21	15	6	2	4	12	19

Figure 28-53 Wattlebank frequency analysis: Flushing flows (1,926 ML/day or greater)

Table 28-50 Wattlebank flushing flows 1,926 ML/day or greater spells analysis

	Pre-development	Full Entitlement	With Dam	Cumulative
No. of events	441	380	379	330
Mean Spell duration (days)	28	26	25	25
Mean Spell interval (days)	52	67	67	82

Overall, the impacts of the Cumulative Impacts scenarios are moderate and will be able to be managed through a combination of environmental flow releases and management rules. These will need to be developed as each item of proposed infrastructure is approved and finalised.

28.5.6. Summary

Three MNES have been identified which could potentially be impacted by changes associated with downstream flow conditions. These include:

- GBR;
- Boggomoss snail; and
- Fitzroy River turtle.

The GBR requires small flushing flows to maintain the physical and chemical characteristics of estuaries and other coastal processes. An assessment of these flows following construction of the dam indicates that no significant changes are predicted both in the With Dam or Cumulative Impact scenarios.

With respect to the Boggomoss snail, an assessment of potential changes to riparian flows was undertaken to determine potential impacts to the snail and its habitat. This assessment identified that the frequency of flows that could directly impact on the snail or strip the riparian zone of mulch will be reduced by the Project. However, riparian flows are too infrequent to be the primary source of water and it is likely that riparian vegetation is reliant on a combination of water sources including groundwater and rainfall, upon which the Project will have no negative impact. The seasonality of these riparian flows is predicted to be maintained. It is therefore considered that the changes to downstream flows within the Isla Delusion and Southend reach of the Dawson River will provide some protection from the damaging effects of floods and is unlikely to significantly impact upon the riparian habitat.

Unlike the GBR and Boggomoss Snails, the Fitzroy River turtle is more reliant on low flows. An assessment of 10 cm, 30cm and flushing flows indicates that there will be minimal change to these flow conditions. More specifically, modelling shows that seasonality of flows is expected to be maintained as will flows for water quality, foraging and movement, leading into and throughout the breeding season.

28.6. Cumulative impacts

Construction of the proposed water infrastructure will also result in a greater number of physical barriers to aquatic fauna movement and migration in the Fitzroy Basin. Where each barrier is fitted with an effective fishway, the cumulative impacts to aquatic fauna are expected to be minimal and acceptable and may potentially improve on the existing situation.

With respect to potential cumulative impacts on the Fitzroy River turtle relating to movement, SunWater commits to the following multi-tiered management approach with respect to turtle passage:

- installation of an effective turtle bypass, specifically designed to facilitate movement of turtles past the dam wall;
- development and implementation of a rigorous monitoring program for turtles, and an adaptive response program where identified outcomes are not being met;
- fishway design which explicitly takes account of the needs of turtles;
- intake tower screen design that prevents turtles entering the system; and
- barrier design that prevents turtles entering downstream release areas where they might be injured by high flow velocities.

Section 28.4.3.4 provides further discussion of the mitigation measures for the Fitzroy River turtle.

Due to the highly regulated nature of the Dawson River (including the existing Glebe Weir) the cumulative impact upon the Dawson sub-catchment and the wider Fitzroy Basin, associated specifically with the construction of Nathan Dam is considered to be low.

While no projects are located directly within the dam study area, a number of water infrastructure, resource and mining development and infrastructure projects are planned within the wider region and along the pipeline. These are listed in Section 28.2.7.1. None of these projects are impacting on the Boggomoss Snail so there will be no cumulative impacts

in this regard. However, the projects are likely to be having varying impacts on Brigalow and habitat for Squatter Pigeon. To meet approval requirements under State and Federal legislation, impacts will be mitigated and offset to ensure no net loss of threatened ecological communities (including Brigalow if applicable) and habitat for threatened species (including Squatter Pigeon if applicable).

With mitigation and offsets, the development of Natham Dam in conjunction with other infrastructure and resource development projects is not expected to have a cumulative impact on Brigalow or Squatter Pigeon in the region.

28.7. Environmental management plan outline

28.7.1. Overview

To demonstrate the commitment of SunWater to ensure that the recommendations of this EIS are implemented, a Draft Environmental Management Plan (EMP) has been developed for the Project. An outline of the Draft EMP has been provided in the EIS. Environmental management practices and strategies for individual Project elements are described in Chapter 29.

The EMP is devised to ensure that identified environmental impacts relating to the Project construction and operation are avoided or minimised. In this regard, the EMP may refer to environmental legislation, controls, standards and guidelines relevant to impact mitigation and avoidance.

28.7.2. Draft construction environmental management plan outline

There are a number of activities taking place during the construction phase of the Project which have the potential to impact on environmental values in the area. These include:

- vegetation clearing;
- land and watercourse disturbance by various construction activities;
- operation of various plant and equipment;
- operation of construction camps;
- construction and use of access and haulage road; and
- upgrade of roads, telecommunication, power transmission and associated infrastructure.

The environmental elements addressed in the CEMP (and agencies responsible for endorsing management measures) are:

- Geology and Soils (DERM)
- Land Contamination (DERM)
- Surface Water (DERM)
- Groundwater (DERM)
- Surface Water Quality (DERM)
- Terrestrial Flora (DERM)
- Terrestrial Fauna (DERM)
- Pest Management (DPIF)
- Air Quality (DERM)
- Noise and Vibration (DERM)
- Waste (DERM and Isaac Regional Council)
- Hazard and Risk
- Transport and Roads (DTMR, Isaac Regional Council)
- Cultural Heritage (DERM)

- Aquatic Flora & Fauna (DPIF)
- Weed Management (DPIF)
- Social & Economic Environment (various)

The CEMP is to incorporate sub-plans that comply with the relevant industry standards for environmental management and must include at least:

- soil erosion and sedimentation management plan for each worksite and for spoil placement areas;
- stormwater drainage and water quality management plan;
- dust management plan;
- noise and vibration management plan;
- vehicle management plan;
- traffic management plan;
- emergency action plan;
- fire management plan;
- land contamination remediation plan;
- vegetation clearance plan; and
- other management plans necessary to achieve the environmental objectives and performance criteria.

28.7.3. Draft operation environmental management plan outline

EMP Element Strategies describe proposed objectives, performance criteria and identified mitigation measures for the operational phase of the Project. Some of the environmental elements suggest specific monitoring requirements and / or statutory requirements and these are described in the following Sections.

The environmental element topics for this Draft OEMP are:

- management of water storage;
- geology and soils;
- water quality;
- aquatic flora and fauna;
- terrestrial flora and fauna;
- pests and weeds;
- transport and roads;
- noise;
- waste;
- hazardous substance ;
- dam safety;
- social and economic ; and
- visual amenity;

28.8. Environmental record of proponent

SunWater Ltd is the Proponent for the Nathan Dam and Pipelines Project. For over 80 years, SunWater has specialised in the investigation, design, construction, maintenance and operation of water infrastructure. SunWater also manages bulk water supply to rural, urban and industrial customers.

SunWater owns and operates bulk water supply and distribution infrastructure located throughout regional Queensland with an estimated replacement value of $6.9 Billion and supplying about 40% of the water used commercially in Queensland via 23 water supply schemes and three subsidiary companies. SunWater services approximately 6,000 water supply customers including mining, industrial and manufacturing companies, local governments, power stations, irrigators and statutory water boards. SunWater has extensive experience in water supply development, and has the support systems in place to enable it to effectively implement the Project and ensure compliance with relevant legislation, including certified quality, environmental and workplace health and safety management systems.

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SunWater aims to achieve a high standard of care for the environment in all its activities — including the storage of water, delivery and management of water services, investigation, planning and design of new infrastructure and the provision of associated technical services. In order to achieve this goal, SunWater has implemented an Environmental Management System, consistent with the requirements of AS/NZS ISO14001:2004 and which is third party certified, across all levels and functions of the organisation.

SunWater's Environmental Management System covers the following:

- development and ongoing management of SunWater's existing and future water supply schemes;
- provision of strategic and routine operations and maintenance services to both internal SunWater clients and external water infrastructure owners;
- planning and design of water distribution and supply infrastructure — this includes project planning, feasibility studies, geotechnical investigations, site surveys, facility design, development of project specifications and performance criteria and project management; and
- refurbishment and construction of water distribution and supply infrastructure.

SunWater is not the subject of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources. One of SunWater's subsidiary companies,

Burnett Water Pty Ltd, was recently involved in proceedings in the Federal Court instituted by the Wide Bay Burnett Conservation Council under the Environment Protection and Biodiversity Conservation Act 1999 (Cth) in relation to Paradise Dam.

28.9. Conclusions

Conclusions drawn with regard to potential Project impacts on MNES are presented below.

28.9.1. World Heritage properties and National Heritage places

The values of the Great Barrier Reef World Heritage Area and Great Barrier Reef National Heritage Place will not be significantly affected by the Project. All of the values cited in relation to these areas are remote from any impact from the Project.

28.9.2. Wetlands of International Importance

The Shoalwater and Corio Bays Ramsar wetlands have values based on supporting vulnerable, endangered and critically endangered species, support populations of species that are important for regional biodiversity and support species at a critical stage of their life cycles.

The Project will not affect these processes and values of the Ramsar site. All of the values cited in relation to these areas are remote from any impact from the Project.

28.9.3. Threatened species and ecological communities

One threatened ecological community will be affected by the Project, Brigalow (dominant and co-dominant).

Clearing within the dam impact area will result in the loss of 200 ha of Brigalow. This will be minimised to some extent by the vegetation clearing strategy. However, as it is not possible to fully mitigate this impact, this will be compensated by the rehabilitation and offset strategies.

Clearing within the pipeline easement and road upgrades has the potential to impact on 1.7 ha and 10.6 ha of Brigalow, respectively. This will be minimised by realigning the final pipeline route to avoid or at least traverse the edges of Brigalow, minimise construction easement width and rehabilitation of the construction easement post-construction. Unavoidable loss of Brigalow will be offset by the offset strategy.

The pipeline route currently runs adjacent to patches of Natural Grassland impacting 0.07 ha. This will be avoided if possible by reducing the easement width.

Database searches indicate that two threatened flora species may occur within the Project area, Hairy-joint Grass and Curly-bark Wattle.

Hairy-joint Grass was not recorded in the Project area, despite targeted searches, therefore, the Project is unlikely to inundate an important population of this species. This species has been recorded in GAB spring wetlands surrounding the FSL, and these springs will be monitored to observe any changes in species composition as a result of likely increased groundwater flows.

The pipeline will result in the clearing of 1.7 ha of potential habitat for the Curly-bark Wattle. This has the potential to impact on individuals of this species which were undetected during the field survey. A pre-construction survey will be undertaken to confirm the presence or absence of this species. Should a population be found, a translocation and/or propagation plan will be developed to mitigate impact. Further rehabilitation of the pipeline easement will be undertaken post-construction to minimise impacts on potential habitat.

Two threatened fauna species will be affected by the Project, Boggomoss Snail and Squatter Pigeon.

The water storage will inundate 0.75 ha of known habitat for the Boggomoss Snail associated with GAB spring wetlands at Mt Rose Station, resulting in the loss of one subpopulation (estimated 350 individuals). Although this represents a small reduction in population size (1.2%) and a small loss of known habitat (1.9%), the loss is of importance as it is the only remaining population that occurs in boggomoss habitat. A translocation plan will be implemented to collect and relocate as many snails as possible from the Mt Rose site to suitable sites outside the impact area. Existing threats to the Boggomoss Snail will be managed at these translocation sites, including weed and pest control, fire management and management of stocking rates. In addition, as part of the offset strategy, riparian habitat will be rehabilitated in and near known habitat downstream of the dam. Compensation (offset) associated with the loss of GAB spring wetlands via the State offset policy may also provide future habitat for the snail.

Squatter Pigeon was frequently recorded throughout the dam study area. There will be a loss of 3398 ha of woodland and open forest habitat for this species within the dam impact area. However, there is approximately 3 million ha of suitable habitat within the region for this species, including abundant habitat surrounding the water storage area which the species can move into. Further, habitat offsets will be provided as part of the offsets package. The Project is therefore considered unlikely to significantly impact on this species.

There are two threatened terrestrial fauna species that may be affected by the Project, Brigalow Scaly-foot and Australian Painted Snipe. A number of mitigation measures are proposed to mitigate potential impacts on these species, including a vegetation clearing and fauna relocation strategy, relocation of habitat features, and weed and pest management. An important population of these species have not been recorded within the Project area, therefore the Project is considered unlikely to have a significant impact on these species, if present.

The only threatened aquatic fauna species potentially impacted by the Project is Fitzroy River turtle. Although the Project footprint is situated within the historic range of the Fitzroy River turtle, none were found to inhabit the dam and surrounds study area during recent surveys conducted by Limpus *et al.* (2007) or those conducted as part of baseline investigations associated with the Project (2007-2008). Following construction of Nathan Dam, the maintenance of downstream water quality, flow regime, and habitat quality/abundance, combined with a nesting bank monitoring program (including rehabilitation efforts if nesting banks fail to rejuvenate), are expected to prevent impact to downstream populations. The incorporation of a functional turtleway into the design of Nathan Dam will ensure the movement of turtles in both upstream and downstream directions and thus, prevent the separation of turtle populations should they inhabit the Project area. The creation of snag habitat within the impoundment will create additional habitat for any Fitzroy River turtle populations that may come to inhabit the area. Overall, the Project is expected to have little to no impact upon the Fitzroy River turtle.

28.9.4. Migratory species

Four listed migratory species have been found in the Project area. The Project area does not support important habitats for any of these species nor does it support an ecologically significant population of these species. Some impacts of the Project are regarded as potentially positive. Hence, the Project would have a negligible negative impact on migratory species listed in the EPBC Act.

Overall, impacts to MNES will be minimised as a result of:

- the initial consideration of environmental factors in the Project design;
- the implementation of Project controls;
- application of appropriate mitigation measures that reduce the impact to the lowest level practically achievable; and
- a commitment by SunWater to implement an offset strategy to compensate residual impacts on threatened species and ecological communities.

28.10. Linkages to EIS

Table 28-51 provides a summary of linkages between Matters of NES addressed in this report and the EIS.

Table 28-51 Linkages with the EIS

Issue	Section of EIS
Project description	Section 2
Relationship with other projects	Section 1
Consequential impacts	Section 1
Occurrence of threatened flora	Sections 10, 12
Occurrence of threatened fauna	Sections 11, 13
Impacts on water quality	Section 16
Impacts on flows	Section 14
Impacts on the GBR/Ramsar Wetlands	Section 13
Impacts on aquatic flora	Section 12
Impacts on aquatic fauna	Section 13
Impact on terrestrial flora	Section 10
Impacts on terrestrial fauna	Section 11
Preliminary operational strategy	Section 14
Impacts on Fitzroy River Estuary	Section 12, 13
Cumulative Impact Assessment	Section 27
Environmental Management Plan	Section 29
Project approvals required	Section 1, Appendix B